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FOUNDED AND EDITED BY

THEO. FEILDEN.

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The Year 1907

has forged another link in the great chain of electrical development which is harnessing up in an almost miraculous manner the stupendous forces of nature at man's disposal. And in the attainment of some great ideals and many meritorious achievements in the past year Britain holds an honoured place among the progressive nations of the earth.

Time was when this country led the way in almost every branch of scientific accomplishment and in every field of industrial activity. But it was inevitable that the great mother of nations should have her supremacy challenged; sooner or later it was certain that she would have to contend with the researches and activity of foreign countries and also to consider the thoughts, aspirations and work of her daughter States.

Those very discoveries by our brilliant countrymen which placed Great Britain at the head of the world's manufacture and commerce roused the school of nations into progress and thus created formidable competitors who have risen up to vie with us in every scientific sphere, in every industrial field. They came to learn and to buy, then to copy, and eventually to fight us with our own weapons. And in this industrial warfare they have been aided by the intelligent support of their respective Governments. The inventive capacity of a long line of illustrious pioneers, aided by our mineral resources and our ability to put them to the best use, gave this land an immense start. But whether it be that the technical education of our rivals has been superior, or their natural resources have been greater, or whether they have attained a higher degree of efficiency and skill, or have been more advanced in their business methods, or whether they have been enabled to foster their industries under better trading conditions whilst we have been content to rely on prestige and inadequate fiscal arrangements—whatever the reason may be, the fact remains that in comparatively recent times an ever-increasing advance has been made by other nations and this country has lost ground in trades which she had made her own. Who would have predicted the conquering achievements of the United States, the immense scientific and industrial advancement of Germany, or, to come right to date, the astounding and unparalleled progress of modern Japan? For years past our country has been faced with a competition of the most tense and severe description, and, from causes which the people of Great Britain are now only beginning to realize, we have seen industries vanish from our midst to be planted and rooted firmly on foreign soil, there to flourish; we have seen thousands of our most skilled artisans and our most capable business men leaving their native shores for fresh fields, and we have had and still have an appalling number of good men out of regular employment. There must be a cause for this deeper than the ability of the scientists, manufacturers, and craftsmen of other nations to rise to new industrial conditions. Were the competition that has beset us — and which is increasing in intensity — on fair and equal lines, Britain need not trouble about the result; instead of capable workmen being turned from our workshops, employment would have been found for all; instead of many of our factories being closed and industries leaving our shores, they would have been retained, strengthened, and extended. And, if a clearer insight into the potentialities of our great Colonies were formed and a wider conception of their aspirations grasped, we could be supplied with all the raw material required for our manufacturing industries, whilst, instead of our buying immense quantities of foreign-made goods, the British Empire could satisfy all the requirements of her people both at home and over-seas. The time has not gone by, however, for a great ideal to be accomplished—for the forward movement that has been begun to reach fruition; it remains yet, despite set-backs to Imperial sentiments and aspirations, to attain a larger degree of prosperity for this country than ever before, unless our people refuse to see the writing on the wall ere it be too late.

Let it be understood that this is no alarmist article; there is no cause for dismay; our country is not decadent, as some would have us believe; far from it. We are materially progressing, but not nearly at the rate by which other advanced nations are ever pressing forward to a goal which threatens to leave us far behind, and there are signs and portents which require more than mere consideration. When we witness the spectacle of hundreds of thousands of tons of "dumped" steel in our midst—the over-production of American manufacturers—at prices which imperil the prosperity of one of our greatest industries, when we are told that a huge line of motor-cars can be put on this market *under cost*, and when we see our maritime trade being practically swept from the Pacific, it is surely time that a definite line of action be taken to protect our trade and commerce. These and other indications of there being "something wrong" are too significant to permit of further delay in obvious reforms.

At the Opening of Another Year

no apology is needed for these remarks. With a heart-felt interest in the scientific and industrial advancement of our country the mind travels to a time when we can be independent of foreign nations to feed and sustain our people. Barter and exchange if you like—that must be as long as the world lasts—but under more sensible conditions. We can look forward with a great hope to the cementing of the ties of kinship with our people over seas, to the accomplishment of a close alliance of the British race the world over. This, not alone on the score of sentiment, but for solid business reasons, should be the aim of every patriotic man who owes allegiance to the King. We are supposed to be a practical people; we have here an occasion to be risen to, to give this belief the greatest proof. The opportunity is now with us to weld together in one indissoluble unit the separate portions of this far-flung Empire into a confederacy of nations that will make for the impregnability of the whole.

Realizing the splendid heritage that has been handed down to us by our illustrious forefathers—not alone in their scientific achievements and manufacturing capacity, but in the shape of the English-speaking lands which fly the Union Jack, lands that are rapidly forming into nations with enormous potentialities, lands that can and will, if allowed, consolidate with the old country, whose Imperial power can be utilized to the full in their development on the best British traditions—realizing this and with the knowledge of the aggressive efforts of foreign nations which have made such inroads into our commerce, both on our own soil here and abroad, the writer has determined to devote himself ardently to a militant propaganda for the attainment of the ideal here outlined and which many earnest Britishers have now at heart. *Trade within the Empire* shall be the watchword, and with this shall come the placing on a reasonable basis of British trade *outside* the Empire.

In this issue of THE ELECTRICAL MAGAZINE I have taken up the subject with reference to the nearest of our great daughter States—the country which is looming so large on the horizon. Electricity is now so universal and enters so much into every phase of modern thought, invention, and manufacture that it is fitting to give it a wide interpretation. What has been attempted in this number is not nearly complete, but it will serve at this juncture. Canada presents opportunities which are only beginning to be realized in this country—opportunities which her statesmen and pioneers have been sagaciously and assiduously demonstrating for years. As a first step, therefore, to a wider exploitation, this issue places certain facts in regard to Canada before British readers, and for our Colonial brethren treats upon the products of representative British firms with the hope and expectation that fruitful results will follow.

* * * * * *

In Conclusion

may I touch upon a personal chord. I have always at the commencement of a New Year come as it were into close touch with my readers, and I wish more than ever to do so now. In January, 1904, I produced the first number of this journal. THE ELECTRICAL MAGAZINE, therefore, with the current issue enters upon its fifth year. The period since its inception has been one of much anxious endeavour and unsparing labour. An uphill battle has had to be fought: many serious difficulties presented themselves, and old prejudices had to be broken down. I have striven throughout to make the Magazine a useful and valuable record of the great interests coming within the scope of its title. As a reflex of electrical opinion the world over, it has attained a large degree of popularity and secured readers in every part of the globe. Its utility is emphasized by the numerous satisfactory letters received from correspondents at home, in the Colonies and foreign countries. In a word, the Magazine has, despite all difficulties and competition, become established as a factor in electrical development to be reckoned with. Its special industrial numbers, particularly those issued during the past year, have been generally recognised as the best things of the kind yet published. The current number opens up a new vista of possibilities. What has been done it is possible to repeat on even more advanced lines.

To British Electrical Manufacturers and those engaged in cognate industries I more particularly address these remarks. THE ELECTRICAL MAGAZINE—the only representative monthly electrical organ in this country—deserves well at their hands. Its assiduous and consistent advocacy of their interests in every part of the world, and its undeniable business-producing qualities, should ensure their continued and ungrudging support.

To readers and friends, one and all, both at home and over-seas, I cordially wish A VERY HAPPY AND PROSPEROUS NEW YEAR.

Theo. Frieden.

LORD KELVIN.

THE GREATEST SCIENTIST OF THE AGE.

PROFOUND regret was universal when the news of the death of Lord Kelvin flashed over the civilized world, marring the close of the year just past. That he was the greatest amongst his many brilliant contemporaries of natural philosophy and science has for very many years been accepted, not only in this country but in all lands wherein the worth and honour of the scientist is appreciated. Yet with this universal sorrow over an irreparable loss there are many sources of consolation: Lord Kelvin was blessed with many years of life—all good and active years well spent in the furtherance of our knowledge of natural forces and their utilization; moreover his genius was appreciated and recognized; he retained to the end his remarkable gifts and the power of applying them to the general good; and to crown all he was blessed with a peaceful dissolution. His death took place after a fortnight's indisposition, on December 17th, at his beautiful home at Largs, on the Ayrshire coast. Such a life as his, extending to almost eighty-four years, merits the writing of a great biography, which will of a surety be done, to the untold benefit of generations of the hard-thinking and sincere searcher after truth.

Lord Kelvin was not a recluse; master of theory and leader of scientific research, he was still an active virile man. In his early years he was an ardent follower of open-air sports and exercise; in his 'Varsity days he won the Silver Sculls and formed one of the winning Cambridge crew against Oxford. In disposition he was genial and unassuming, and in the later years, when honour and renown brought him the highest distinctions from all over the world, his reference to them and his general bearing was always modesty itself. With these manly characteristics there was the further refining (if we may so term it) quality of a deep religious sense. There is such a prevalence amongst the followers of natural science of a disbelief in creation and in the existence of a controlling spirit in the endless progress of the universe, that this phase of Lord Kelvin's life should be widely known—for indeed no man had ever clearer knowledge and a more definite understanding of the beginning and end of all things—of the forces and causes which make of the star a sun, of the sun an earth, and of an earth a moon. The arrogance of the scientist who, with test tube in hand, himself makes changes in matter, the which he can so easily explain to the hilt by the deft use of formulæ, will receive a rude check when he comes to consider why it was that Lord Kelvin throughout his life and to the end held an ever-increasing belief in the Divine existence.

Born on 26th June, 1824, in Belfast, William Thomson was of Scottish parentage. His father, James Thomson, LL.D., was at that time the Professor of Mathematics at the Belfast Academical Institute, but in 1832 he became the Mathematics Professor at Glasgow University. Since that time Lord Kelvin's connection with that seat of learning was practically unbroken. He entered the Glasgow University when eleven years old and subsequently proceeded to Cambridge at the age of seventeen, where he graduated second wrangler. In 1846 he was elected a fellow of his college, St. Peter's, and in that year also he became Professor of Natural Philosophy at Glasgow, a position which he occupied for fifty-three years.

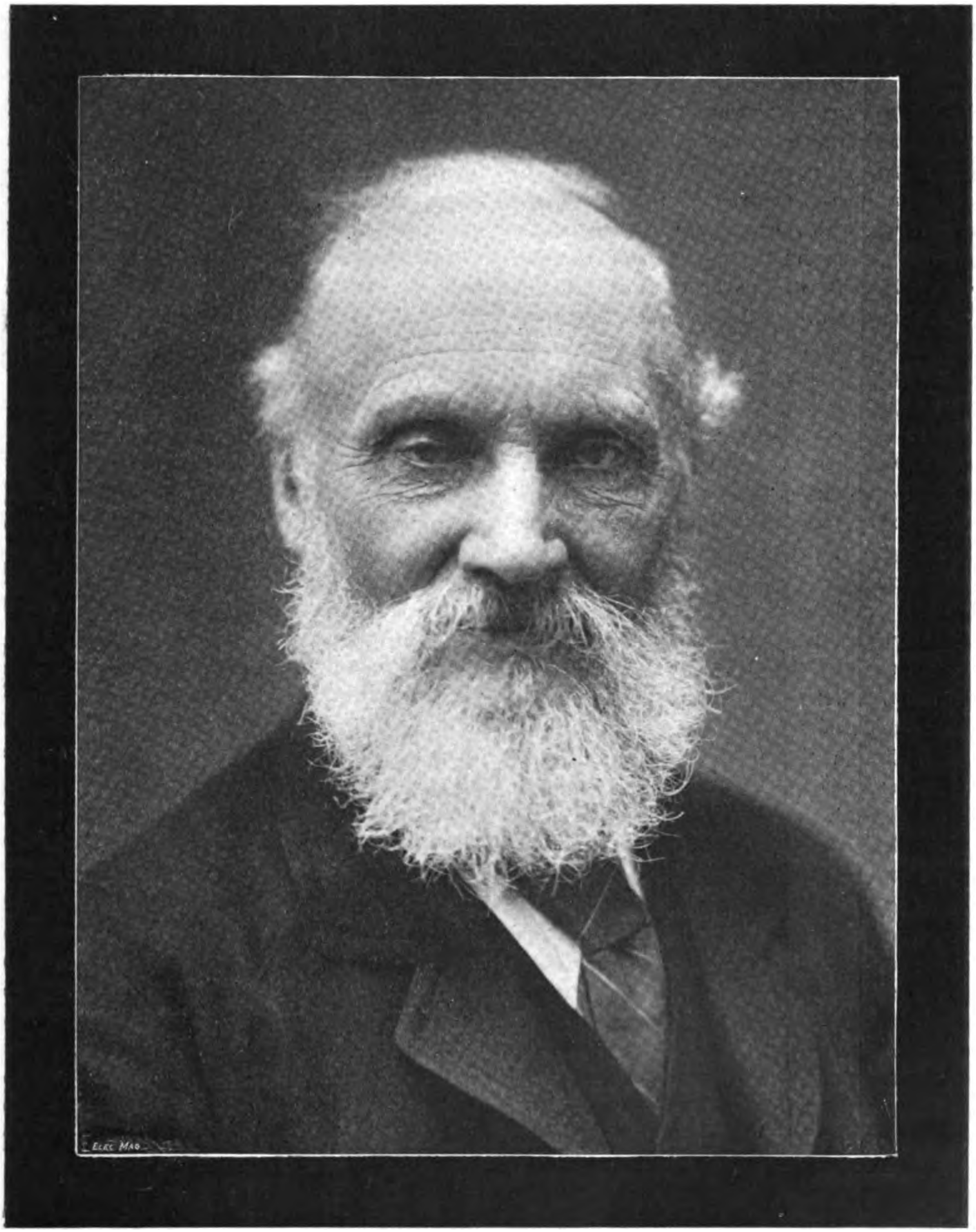
It is well known that Lord Kelvin was far more than a college professor. It is very evident that he was also a great engineer and inventor, and further than this that he was a commercial man. His profound theoretical researches were ever accompanied by a keen sense of their commercial value. It would be impossible here to enumerate the long series of inventions evolved by Lord Kelvin or to indicate the immense value which so many of them were to the world at large. William Thomson was rewarded with a knighthood in the year 1866 for his invaluable work in the principles underlying submarine telegraphy and his invention of the sensitive signal receiving and recording instruments which rendered the submarine telegraph a commercial success. At the present day the most accurate electrical measuring instruments are those devised by Lord Kelvin. Whilst in the main his inventions were of electrical interest, there were many of a more or less mechanical nature: the introduction of iron ships called for his inventing the shielded mariners' compass now used on every vessel afloat; there is a highly effective water-tap on the market which also bears "Kelvin's Patent." The versatility and the combination of the highest theoretical knowledge with practical application were the means of Lord Kelvin gaining a large fortune. He was connected with many commercial concerns, engineered a number of important submarine cable systems, and was consulting engineer and adviser to several electric and telephone companies.

It was in 1892 that Sir William Thomson became Lord Kelvin, he being at that time President of the Royal Society. He was a Privy Councillor, G.C.V.O., and was one of the first to be awarded the Order of Merit by King Edward. He was also decorated by several foreign rulers, including those of Germany, France and Belgium, and, of course, was the honoured member of many British and foreign scientific societies.

We can but give a brief insight into Lord Kelvin's career and personality. As we have seen, the one was long beyond the average, ceaseless in its activity, and priceless as a continuous record of well-directed genius; as to the other, his personality, we know that he was universally esteemed by his contemporaries, that he was generous and of a kind nature, that he delighted in natural, health-giving pursuits, that the rewards showered upon him did not beget conceit, but that he was to the end, as always, a genial and companionable man. Not only has the electrical profession lost its greatest light in his decease, the whole civilized community feels that a master mind is no more. There is but one phase now for all to bear in mind—Lord Kelvin rests with the immortals of the British race in Westminster Abbey, the shrine to which we all at times turn for inspiration. None rests there more worthy than he. As the years and generations pass he shall not receive the less of that hero-worship the exercise of which is all to the great encouragement of the individual and the advancement of our nation.

"Lives of great men all remind us
We can make our lives sublime,
And departing leave behind us
Footprints on the sands of time."

* * *



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LORD KELVIN.

HIGH-TENSION INSULATORS.

C. E. DELAFIELD.

THE science of properly and safely insulating line voltages of high potential has not kept pace with the demands of transmission engineers, and to-day we are face to face with the problem of successfully transmitting potentials in excess of 100,000 volts. In California power is transmitted at 60,000 volts more than 200 miles, but great line losses are suffered and the investment in copper is heavy. An increase in voltage from 60,000 to 150,000 would make it possible to deliver this power with reasonable losses and in much greater quantity. As an illustration of the possibilities of delivering power at 150,000 volts, the power generated at Niagara Falls could be economically delivered to Boston, New York, or Philadelphia, and, apparently, the principal hindrance to this consummation at the present time is in the fact that there is not on the market what might be termed a successful insulator for this enormous voltage, although the merits of a number of different types of insulators are at the present time being advocated for this purpose.

The design of an insulator for high voltages should involve a consideration of all the effects of electrical tension on the dielectrics in the vicinity of the conductors. In the case of a line insulator, air is always a dielectric in combination with wood, porcelain, glass or other materials, and, wherever there is a difference of electrical potential, there exists in the surrounding media a certain state of strain. It frequently happens, when several dielectric materials are subjected to the same electro-static field, that one or more of the materials will be strained beyond the limit and fail, although the others will stand the electrical tension. Air frequently fails in this manner, thus giving rise to the well-known brush discharge. The structural failure of air from an engineering standpoint has been studied by a number of investigators, and it is well known that air at the ordinary pressures and temperatures has a much lower dielectric value and strength than the common insulating materials. Air in thin films, adjacent to solid bodies, has greater strength than in bulk, and is still inferior to such substances as glass and porcelain. The dielectric strength of air is affected by its physical condition, and varies directly as the pressure and inversely as the absolute temperature. Under uniform conditions dielectrics rupture at definite applied tensions. There exists for each dielectric material a certain strength of electro-static field, which will cause a rupture.

These being the fundamental rules by which designing engineers formulate their plans for the manufacture of insulators for varying potentials, it can well be seen that the various forms of insulators on the market to-day are the results of working out these rules by different individuals looking at the same thing from a different standpoint. That is to say, climatic and geographical conditions exert considerable influence in the design of an insulator. Insulators suitable for dry atmospheric conditions would not be suitable for a condition where sea fogs and dust exist, and there is no question but that a correct solution will soon be forthcoming for a standard insulator for voltages of 75,000 and upwards.

Looking over the history of high-tension transmission, it is only about fifteen years since we looked with wonder on the Lauffen transmission line of 30,000 volts over 100 miles. To-day there are thousands of miles of long-distance transmission at voltages ranging from 11,000 to 65,000 volts, and great credit is due to the engineers who have designed and carried out this work in the face of almost insurmountable obstacles. The progress of high-tension transmission has been very rapid and in all the various branches, with the exception of the line insulators, it is now possible to handle voltages in excess of 75,000 volts, there being no difficulty whatever in the designing and manufacturing of successful transformers and switchboard apparatus for these high potentials. In the future designing and laying out of transmission lines there should be taken into consideration the possibility of increasing the present voltage to the voltage that may be possible a year or more from now, so that large quantities of power may be economically distributed over long distances.

It has been demonstrated by practice that very large generating units can be successfully operated, and that both steam turbine and hydro-electric plants can be operated successfully, and the one question to be decided is—How can large powers that are so successfully generated be distributed over long distances economically, taking into consideration the high prices of copper and aluminium? The answer to this question is —by high voltages only. Up to the present time the commonly accepted form of insulator is what is known as the pin type, meaning by that an insulator having for its resting-place a pin embedded in, or fastened to, a cross arm, this pin being of wood or metal. Present practice has demonstrated that wood can be safely accepted for insulator pins up to 25,000 or 30,000 volts. Beyond that it is advisable, for mechanical reasons, to use malleable iron, but the so-called pin type of insulator has reached such dimensions, in the endeavour to meet the requirements for higher voltages, that it seems to be the consensus of opinion of the leading high-tension engineers that this type of insulator has reached the limit of good line construction, and, when one stops to think of the dimensions of an insulator used on a 60,000-volt transmission, one is inclined to think that the engineers are correct. Not only is it a difficult matter, from a mechanical standpoint, to find a pin that will take the necessary stress incident to an insulator of this large size and weight, but the problem of manufacture, from the standpoint of the pottery, is one that is exceedingly difficult, so that apparently it is necessary to make a radical departure from the present practice of pin insulation in order to take care of the various difficulties that are encountered in the construction of insulators for the higher voltages, and it is the belief of the writer, and also of other engineers, that a suspended form of insulator will be the type which will be used, it being, from a mechanical standpoint, a comparatively simple matter to suspend any desired weight, and, from an electrical standpoint, it seems possible so to design an insulator that it will be mechanically strong and a good dielectric as well.

The suspended type of insulator would have the advantage that ample arcing distance could be provided without making the insulator top-heavy and difficult to manufacture. It should be so designed that arcing cannot occur until the voltage is sufficient to rupture the air and cause the current to arc from end to end, this feature being of great importance where the insulators are mounted on steel towers, which is conceded to be the best engineering practice. On high-voltage lines where steel towers are used the pin type of insulator for 100,000 volts or higher would seemingly be almost an impossibility, owing to the size necessary to take care of the surges and other line disturbances, and owing to the fact that the earth potential is carried into the head of the insulator by the steel pins and through the metal towers.

An ideal insulator, for all conditions of high-voltage stress, should be one that would take care of climatic conditions, such as fogs, dust deposits, salt spray, &c., and should have as few still air spaces as possible. That is to say, it should expose a large part of its surface to the wind and should have a long leakage distance of small area. In the designing of a type of porcelain insulator for this class of work, it should be borne in mind that cemented parts, if there are any, should be under compression and not under tension, owing to the strains to which it may be subjected to form expansion and contraction. There should be as few still air spaces as possible, to avoid the accumulation of dust, insects, &c., and there should be nothing but porcelain, well vitrified, between the points of opposite potential. Engineers are now at work along these lines, and, as the result, a number of plans have been proposed embodying more or less these ideas, and it is only a question of a short time before the successful insulator will be evolved for these higher tensions, if it has not already come to pass.

Leaving for the time being the open question of extraordinary potentials, we will take up the question of high-tension transmission as it exists to-day. Continuous operation of a transmission system is an absolute essential, and depends to a large extent on the effectiveness of the insulator used. In this paper the writer only aims to discuss the qualities of porcelain insulators, as it is now generally conceded that porcelain is superior to glass for the manufacture of high-tension insulators, and, in fact, supersedes glass wherever the question of cost is not a paramount problem. In the designing of an insulator for any given voltage, and especially for the higher voltages, there are three considerations of primary importance: First, electrical design; second, the mechanical strength; and third, the quality of the material.

In the electrical design, consideration must be taken of the dielectric strength of the adjacent air, so that sufficient distance be allowed between the points at which the line voltage is impressed that it will not arc over to the pin or cross arm under ordinary working conditions. In other words, make the potential gradient as gradual as possible from line wire to ground. These points of impressed voltage may vary greatly in an insulator of poor manufacture, although of the same electrical design. For instance, in two insulators of the same general design and different manufacture, the one having the greatest electro-static capacity and therefore the greatest electro-static field, will suffer from brush discharge and arcing over sooner than one having less electro-static capacity, and therefore less electro-static field. In another case, two insulators of the same design but of different manufacture, the one possessing a body of greatest density and which is the most vitreous, will carry ordinary working voltages and line disturbances with less trouble than an insulator that does not possess these qualifications.

Due care must be exercised in the manufacture of porcelain insulators to secure the necessary dielectric strength between the tie wire or top groove and the point inside the insulator which is in closest proximity to the head of the pin, providing that pin is made of iron, which is usually the case in voltages in excess of 30,000; in many cases misfortune has come to the engineer who depended to a large extent on the pin and cross arm for additional insulating qualities. Practice dictates the fact that on the insulator alone should be the reliance of the engineer for his insulation, and all insulators, whether of porcelain or glass, should be tested with approximately three times the full line voltage brought to the inside of the insulator head, and the entire burden of correct and sufficient insulation should be placed on the insulator itself; by doing this a large number of line troubles will be prevented.

It has been the unfortunate habit of some engineers to consider the cost of the insulator of paramount importance, and when one takes into consideration the importance of the insulators to the construction of a line, one is always led to wonder why, by the additional cost of a few pence to each insulator, a reasonable factor of safety is not obtained. It is, however, pleasing to note that many engineers are profiting by the sad experience of their brothers and are securing their insulators based on specifications that insure a reasonable factor of safety, and, in fact, are in some cases going to the other extreme and not only require the manufacturer to guarantee their insulators to stand a rigid test, both before and after erection, but in one case which the writer recently noticed an additional clause was inserted requesting the manufacturers to guarantee that the railway would not break them in transit, which, we will have to agree, was rather a severe test.

Reverting once more to the electrical design, it is necessary in the design of an insulator that the factor of safety be sufficiently large so that the abnormal electrical strains that may be, and are, occasionally brought to bear, will not cause a puncture and consequently a shut-down of the line. For instance, an insulator designed to carry 50,000 volts should stand a dry test of approximately 150,000 volts, thus giving a fair factor of safety to enable it to withstand the possible surge voltages caused by short circuits, &c. This very fact of requiring a reasonable factor of safety in the electrical and mechanical design of an insulator has decided the limiting possibilities of the pin type of insulator as approximately 60,000 volts line voltage, as, to secure a factor of safety of three, it would be necessary to build an insulator of mammoth proportion and uncertain body, having a weight that is almost prohibitive to pin work. This brings us again to the conclusion that the only method of securing a proper factor of safety on the higher voltages would be to use a suspended type of insulator.

Having discussed the engineering design

of a high-tension porcelain insulator, the writer thinks it might be of interest to take up its composition and the difficulties of manufacture, concluding with the tests to which all insulators should be submitted before being placed on the line. The porcelain of which a high-tension insulator is made is composed of certain proportions of English ball, China clay, some domestic clay, commonly called Tennessee, and some feldspar and quartz. The clay forms the body and gives the proper mechanical strength, while the function of the feldspar and quartz is to act as a flux and thoroughly permeate all the parts of the insulator, thus making a thoroughly vitreous mass when subjected to a sufficient heat. This mixture having gone through the various steps of grinding is forced through a filter of copper or silk cloth of 110 mesh to remove all impurities, and is then formed in the various shapes and designs suitable for the purposes for which it is to be used, and placed in the drying room. After a sufficient amount of moisture has been removed in this way the insulators are dipped in the glaze solution and are again placed in the drying room, after which they are placed in the kilns and subjected to a heat approximating 2700deg. Fahrenheit. The function of the glaze is to give the insulator the necessary colour and also a smooth, even surface, in order that dust and rain may be easily dispelled. Ordinary unglazed porcelain would come from the kilns a pure white colour with a comparatively rough surface, which would hold the dirt and moisture, so that it is necessary to glaze the insulator in order that a smooth, glassy surface may be obtained, as well as the desired colour. If, in baking, the insulator is not subjected to the proper amount of heat the body of the clay will not be thoroughly vitrified. If, on the other hand, the insulator is subjected to too much heat the body of the clay will be porous. Therefore, it is necessary that the insulator be subjected to the exact amount of heat necessary to secure the desired results.

In determining the exact amount of heat to which these insulators shall be subjected, ordinary thermometers are not used, but a small carefully prepared cone of pre-determined composition is utilized, which is placed at intervals in the kilns and is observed through small orifices by the attendant. These cones maintain an erect position under any degree of heat below the desired one. As soon as the pre-determined point has been reached, however, the cones melt and form glaze, and at this point the heat is turned off and the ovens allowed to cool slowly, so that the ware may be thoroughly annealed. This process cannot be hastened but takes a certain well-defined time for its operation. When removed from the kiln the insulators are then subjected to a most rigid electrical and mechanical test to determine their qualifications for the work which they are designed to do, and all those not coming up to the specifications should be rejected at this time. A certain number ot all insulators coming from the kilns are subjected to two electrical tests, one a dry test to determine the dielectric strength of the porcelain body, and the other a precipitation test to determine as nearly as possible the action of the insulator under most severe climatic conditions.

The only objection that has been offered to porcelain as the composition of which the insulator should be made is the fact that in no other way than the above-described can a porcelain insulator be properly tested, whereas the defects that might occur in glass can be detected by the eye. Unless an insulator is thoroughly vitreous and is practically non-absorbent and shows a fracture similar to glass, it is unfit for use under high-potential stress.—*The Central Station.*

Tantalum.

The principal ores of tantalum are tantalite and columbite (a combination of iron, tantalum and columbium), which occur in pegmatites or coarse granites.

The metal has some remarkable properties. It is not attacked by hydrochloric, nitric or sulphuric acids, aqua regia, or alkaline solutions. It can be drawn into fine wire having a tensile strength greater than soft steel. A red-hot lump of tantalum may be at once hammered into a plate which, on repeated re-hammering, becomes as hard as diamond. A diamond drill running continuously for three days at 5000 revolutions a minute failed to penetrate such a plate, although it was but one millimetre thick, while the drill was much worn.

A British patent has been obtained for making writing pens from tantalum, whose hardness, elasticity and resistance to corrosion would seem to fit it well for such use.

ELECTRO-MAGNETS FOR LIFTING.

THE number of commercial magnets actually in use for lifting purposes is relatively small, taking into consideration the large number of plants which could profitably employ lifting magnets for handling various forms of raw metals and finished parts entering into the products of their manufacture. This condition is doubtless in a large part due to the fact that the advantages of lifting magnets are not generally realized, for it is worthy of note, says a writer in the *Western Electrician*, that no concern which has given the lifting magnet a fair trial has returned to the old method of handling iron and steel.

Wherever pig-iron, metal plates, tubes, rails, beams, scrap or heavy castings of iron or steel are handled, lifting magnets can be advantageously employed. The saving in time in adjusting hoisting tackle to the object to be raised is of itself oftentimes sufficient to justify the installation of a lifting magnet, while in the case of pig-iron, plates, rails, and scrap, the practical advantages of lifting magnets are still more obvious, owing to the large number of pieces that can be handled at a single lift, and to the fact that the objects so handled need not be piled beforehand. All that is necessary in work of this sort is to lower the magnet down to the objects to be handled, switch on the current and lift. A further advantage of lifting magnets is found in the fact that metal too hot to be touched with the fingers can be handled as easily as cold metal.

Various forms of material require various forms of magnets. The construction of magnets for handling plates or material of a similar nature, affording opportunity to secure an intimate magnet contact, is a comparatively simple problem. In such cases the principal care of the designer will be to provide means for securely anchoring and properly insulating the magnetizing coil. Calculations as to the lifting capacity of such a magnet can be made with considerable accuracy, as the total flux is easily figured.

Magnets for handling billets, rails, &c., laid in piles, are, as a rule, operated in pairs. Such material usually comes in 50ft. lengths, and is most conveniently handled by two magnets placed about 18ft. or 20ft. apart on a balancing bar to which the crane hook is attached.

Magnets for handling pig-iron, scrap, &c., present the greatest difficulties in design. Such magnets are expected to handle a wide range of material, varying in form, in magnetic permeability, and often encountered in irregular piles; hence the reluctance of the magnetic circuit, and consequently the total flux will vary with each lift. This makes accurate calculation of total flux almost impossible, and experience absolutely essential to the production of a thoroughly good magnet.

By a "good magnet" is meant one which

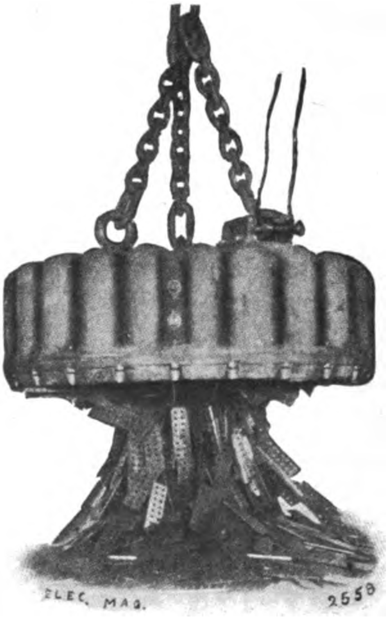
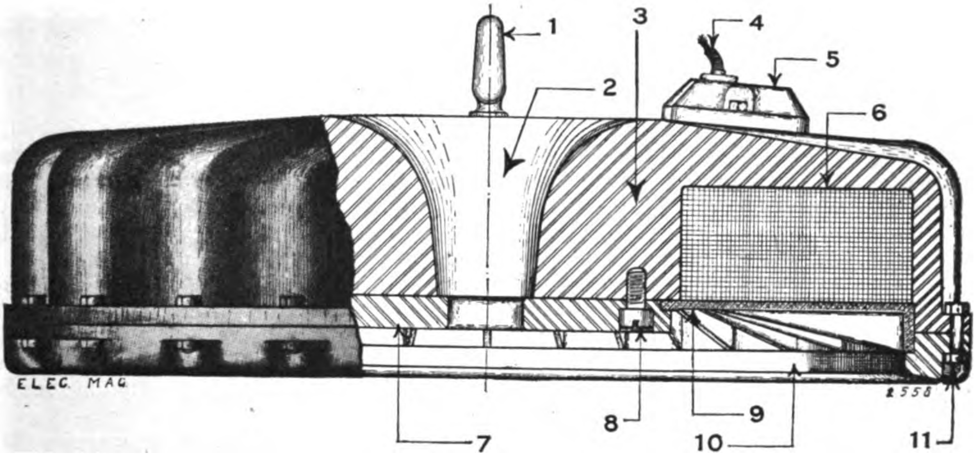


FIG. I. LIFTING MAGNET HANDLING IRON STAMPINGS.

will lift, in proportion to its own weight, the greatest possible amount of material. The weight of the magnet itself must be considered as dead weight, and the aim of the manufacturer, therefore, is to construct a magnet that shall combine the minimum of weight with the maximum of lifting capacity.

Other things being equal, the larger the magnet the greater its lifting capacity, and just here is the crux of the magnet problem, for only the most intimate knowledge of electro-magnetism, combined with practical experience in building lifting magnets, will enable one to know the exact point at which any further saving in weight will be accompanied by a more than corresponding decrease in efficiency.



1. One of three eye-bolts.
2. Central flue.
3. Magnet body.
4. Cable.
5. Terminal box.
6. Coil.
7. Inner pole-shoe.
8. One of several screws fastening inner pole-shoe to magnet body.
9. Coil body shield (brass).
10. Outer (removable) pole-shoe.
11. One of the through bolts fastening outer pole-shoe to magnet body.

FIG. 2. DETAILS OF LIFTING MAGNET.

Another point must be borne in mind. While it is true that the weight of the magnet itself must be considered as dead weight, still it may sometimes happen that, as between two magnets, the heavier may actually be the more economical of the two. The material handled by lifting magnets is seldom simply hoisted—it is hoisted and conveyed. While the power required to hoist is directly proportional to the load on the crane hook, this does not hold true with regard to conveyance, for the weight of the crane itself forms so large a proportion of the total load to be moved along the track, that a larger dead weight, which, lifting more, will reduce the number of trips made by the crane, may show a marked saving, both in time and current consumption.

The Cutler-Hammer magnet, as illustrated, recently placed on the market, embodies several new features, and under competitive tests has developed a lifting capacity showing an efficiency perhaps never before attained.

In the design of this magnet the magnetic attraction of the inner pole has been purposely made stronger than that of the outer pole. The practical effect of this concentration of the magnetic flux on the inner pole is that in handling iron pigs or similar material the various pieces constituting the load are released by the outer pole first, when the current is switched off, and are drawn toward the centre of the magnet by the superior attractions of the inner pole, thus enabling the operator to deposit the load within an area scarcely exceeding in extent the diameter of the magnet itself.

Every prospective purchaser of a lifting magnet naturally wants to know the amount of current consumed, that he may calculate intelligently the saving that may be reasonably expected in handling material with this labour-saving device.

The following data, obtained during the test of a 52in. Cutler-Hammer magnet at the plant of the Youngstown (Ohio) Sheet and Tube Works, throw light on this point:

Total weight of pig-iron unloaded from steel gondola car	109,350lb.
Weight of average lift	785 ,,
Number of trips required to empty gondola	139
Current on magnet	1hr. 15min.
Current off magnet	50min.
Total time consumed	2hrs. 5min.
Current required	30 amp. at 220 v.

From the foregoing figures the cost of operation is easily figured, the cost of current per kw.-hour being known. Thirty amperes at 220 volts corresponds to a power consumption of 6600 watts which was required for one hour and fifteen minutes. This gives a total power consumption of 8.25 kw.-hours, which at 1½d. per kw.-hour gives a total of a little more than one shilling—cost of current for energizing magnet during the period required to unload fifty-four tons of pig-iron.

It is believed that the excellent performance of the particular magnet under test is due to better coil construction, securing greater magnetic flux with equal weight of copper; better proportioning of the magnetic circuit insuring deeper penetration of the flux into the material to be lifted, and in no small measure to the careful attention given to the important question of heat radiation.

In reference to the shape of the magnet it is to be remarked that while a concave-faced magnet is admirably adapted for handling pig-iron, it is not well suited for lifting ingots, or other long objects with plain surfaces, owing to the fact that the inner pole cannot come in contact with the object to be lifted. By means of the auxiliary pole-piece, however, this difficulty is overcome.

The commercial applications of magnetism are not limited to lifting magnets. In the ordinary run-of-mine coal, pieces of iron, such as spikes, cable-pins, broken pick heads, &c., frequently find their way into the chutes, with disastrous results to the coal-crushing machinery. At the plant of the Maryland Steel Company the run-of-mine coal is carried about 25ft. above the ground level by means of a conveyor, and allowed to pass down the chute, from which it is discharged into a second chute. Magnets are placed behind an opening between the first and second chutes, and cause any pieces of iron, which may be mixed with the coal, to be deflected sufficiently to prevent them from passing into the chute which feeds the coal into the crushers.

Cost of Cooking by Electricity.

A DETERMINATION of the cost to the average family of cooking by electricity is difficult to make because of the scarcity of authentic figures and the varying conditions in different cities and families. The following letter published by the Portland (Oregon) Railway Light and Power Company from one of its customers gives some data on the subject.

The outfit that I have in use consists of the following devices:

One oven.
One broiler.
One 8in. disc stove.
One 7in. frying pan.
One coffee percolator, 300-watt size.
One 5in. frying pan.
Two 2-quart combination cookers.
One chafing dish.
One 1-quart water heater.

The average amount of current consumed per day during the test was 2.76 kw.-hours, which at 5 cents per kw.-hour amounts to 13.8 cents (7d.) per day, or $3.87 (16s. 4d.) for the twenty-eight days of the test.

The first two weeks of the above record there were two in the family. The last two weeks there have been three. The cooking has been done by my wife all of this time, and all of our cooking has been done on the electric outfit.

Therefore, the cost per person per day was 5½ cents.

In comparing this with gas I beg to advise that my gas bill used to run for the same service from $2 (8s. 4d.) to $3.50 (14s. 7d.) per month, depending on the time of the year. On a similar corresponding period I think the charge was about $2.75 (11s. 6d.) per month.

The advantages of the electric outfit which would offset the difference in charge, in my opinion, are the cleanliness of the utensils and the easiness with which they are kept clean; also the absolute lack of offensive odour during the operation of cooking. The latter reason is practically the strongest point for use in this town, as it was the principal cause which led me to install the electric outfit. My wife used to be so nauseated from the offensive odour of the gas that she was practically unable to eat after cooking the meal.

ELECTRIC SLEEP AND RESUSCITATION FROM ELECTRIC SHOCK.

A. GRADENWITZ.

Owing to the obvious drawbacks inherent to the familiar processes of anæsthesia, endeavours have been made to replace them by a more harmless kind of insensibility. Mention may be made of the observation made a few years ago by a Swiss physician, Professor Redard, that rays of blue light, when allowed to act on the eye for a short time, will cause a suspension of sensitiveness to pain. This phenomenon has been utilized especially in connection with dental operations.

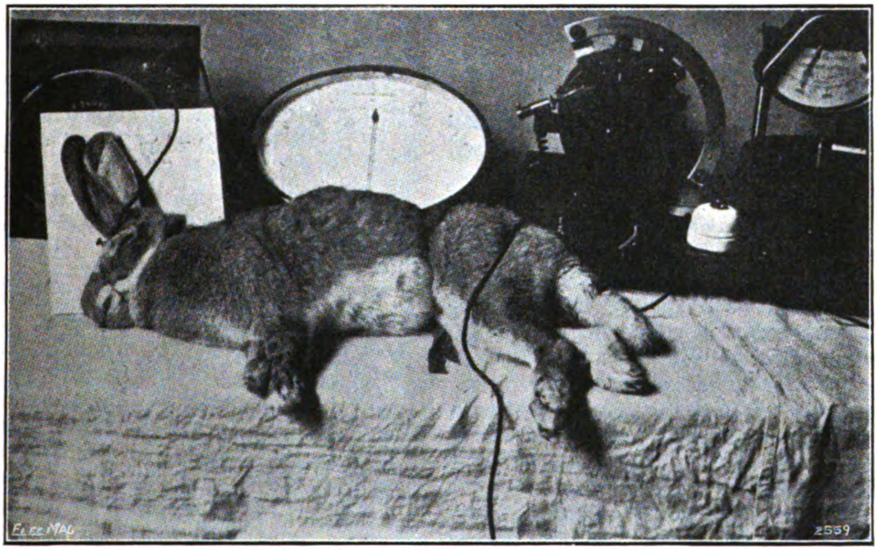


Fig. 1. Rabbit under the Influence of "Electric Sleep."

Another more promising process has been developed by Professor Leduc, of Nantes. This consists of submitting the body of the patient to the action of a peculiar kind of electric current, namely, a low-tension direct current, interrupted and re-established at frequent intervals. This current is readily utilized for the production of local anæsthesia, and good results have been obtained, there being no objectionable after-effects. Most interesting observations have been made also by producing with its aid a general insensibility of the body, or, in Leduc's term, "electric sleep." While only local electric anæsthesia can at the present moment be used for the purpose of performing surgical operations, the phenomena brought out by the investigations are extremely interesting from the scientific point of view.

A systematic research of electric sleep has been recently conducted at Professor Leduc's laboratory by Dr. Louisa G. Robinovitch, when the remarkable fact was observed that "electrocuted" animals can be restored to life by the rhythmical application of electric currents. Before describing this experiment, which the writer recently had an opportunity of witnessing, a short abstract of Dr. Robinovitch's researches will be given.

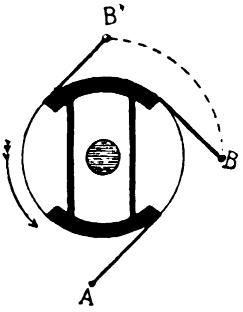


FIG. 2.

The current used for producing electric sleep is direct current interrupted at frequent intervals, the most advantageous rhythm being 110 interruptions per second. This frequent interruption is produced by a special apparatus designed by Leduc. (See Fig. 2 above.)

On a horizontal axis rotated by a small electric motor there is mounted an insulated wheel carrying an armature of metal pieces, forming intermittent contacts at the surface of the rim. On the latter there are sliding two brushes (A) and (B), the circuit being closed only when the two brushes are simultaneously in contact with the metallic armature. One of these brushes (B) can be shifted alongside the rim so as to be in contact with the metallic armature only during say, one-half, one-quarter, one one-hundredth or even a smaller fraction of the time during which the fixed brush (A) is in contact with the same armature.

When in the position (B') the movable brush will allow the current to pass during half the time of rotation of the wheel, and in the position (B) will allow no current to pass. Between these extreme positions there is a series of intermediary stages, each of which corresponds to a given period.

Dr. Robinovitch recommends using the current supplied by a storage battery, while another battery is used to actuate the motor of the interrupter. The negative terminal (cathode) of the circuit should be applied to the head of the animal, as with the anode at its head the respiration of the subject is greatly accelerated, while its temperature will rise to objectionable figures. It is preferable not to submit the animal suddenly to the whole of the dose of current required to produce electric sleep, as in this case, at the moment the current is completed, a rather considerable disturbance of respiration and of cardiac functions is nearly always produced.

The pupils of the animal when in the state of electric sleep are not dilated as during epilepsy; on the contrary, they are contracted to some extent. The temperature of the body will drop somewhat below the normal figure, while the rhythm of respirations differs only slightly from the normal. There is nearly always an increase in arterial pressure observed during electric sleep as in the case of other anæsthesia.

Professor Leduc has submitted himself several times to the suspension of cerebral functions designated as electric sleep. A large electrode consisting of wadding soaked with salt water and a metal plate was placed on his forehead and tied round his head. This frontal electrode formed the cathode. Another electrode of considerable dimensions prepared in the same manner was fixed to the abdomen. The current passing 100 times per second was established gradually. The sensation produced by the excitation of surface nerves, although disagreeable, could be readily withstood, and was appeased as time went on. In fact, after passing through a maximum the sensation was found to diminish in spite of an increase in the electromotive force. The face was red, and there were slight convulsions of the facial muscles as well as of the neck and even of the forearm, and fibriller tremors were observed, followed up by a pricking feeling at the finger tips and even in the feet. The inhibition due to the electric current first affected the centres of speech, after which the motive centres are completely inhibited, the subject being unable to respond to even the most painful excitations or to communicate with the experimenters.

While the current was at its maximum Leduc heard as in a dream the conversation of those standing by his side and had perfect consciousness of his inability to move and to communicate with his colleagues. He still felt any contacts and pinching of the forearm, but all his feelings were deadened, as though the member in question had gone to sleep. The most painful impression was to watch the gradual dissociation and disappearance of all faculties, these impressions being similar to those felt during a nightmare. However, Leduc was still able to regret the premature discontinuance of the experiments, the latter being stopped before perfect insensibility was produced. The awakening was instantaneous, and no after-effects other than a feeling of special well-being was stated.

It is interesting to observe the production of complete electric anæsthesia in animals, and this experiment was demonstrated to the writer. After the circuit has been completed the animal (usually a rabbit) seems to manifest surprise, raises its ears and soon becomes restless. As the current is increased the rabbit tries to escape, but it does not cry, nor does it seem to suffer. The animal next passes through some slight convulsions, manifested by tremor in the legs and the face, while its neck becomes rigid; it then falls on its side. The rigidity gradually disappears, and after some slight efforts to lift its head the rabbit closes its eyes and seems to be asleep. Apart from very slight tremulations in the forelegs and in the muscles of the face it is now perfectly calm, both its respiration and cardiac beatings continuing regularly. The electromotive force required for producing this state is generally from five to six volts, with a current intensity of one milliampere. The animal may remain in this state as long as desired; in fact for many hours. If, instead of this low potential, a pressure of say 55 volts be applied for a short period (say four seconds), the circuit being opened immediately afterwards, some very curious phenomena, resembling an attack of epilepsy, are produced. A few seconds after the circuit has been opened the subject exhibits tonical convulsions, white foam appears at its mouth; the animal grinds its teeth and sometimes gives off slight cries. A clonical phase then ensues, and these convulsions, occurring at regular intervals, are followed by a stage of coma lasting from a few minutes to half an hour. This experimental epilepsy is thus seen to be strictly analogous to pathological epilepsy. The respiration and cardiac beatings do not seem to be influenced to any material degree by the passage of the current, the effect of which is limited to an alteration of the nervous system giving rise to a subsequent epileptic crisis. If then a Leduc current of 12 to 15 volts pressure be allowed to act on a rabbit during half a minute or a minute, a real electrocution of the animal can be produced, and the rupture of the current does not suffice to restore it to normal conditions as in the case of electric sleep. On the contrary, the cardiac beatings are found to have ceased entirely and respiration has been likewise discontinued. These two symptoms have been so far regarded as characteristic of what is termed physiological death, and no resuscitation of a subject in this state had so far been on record. However, Miss Robinovitch in most cases does succeed in restoring these animals to life by applying a rhythmical succession of current impulses, the rhythm corresponding to that of respiration so as to produce a process analogous to artificial respiration.

These phenomena are represented in the tracing below, Fig. 3, which shows (in the upper part of the figure) the curve of respira-

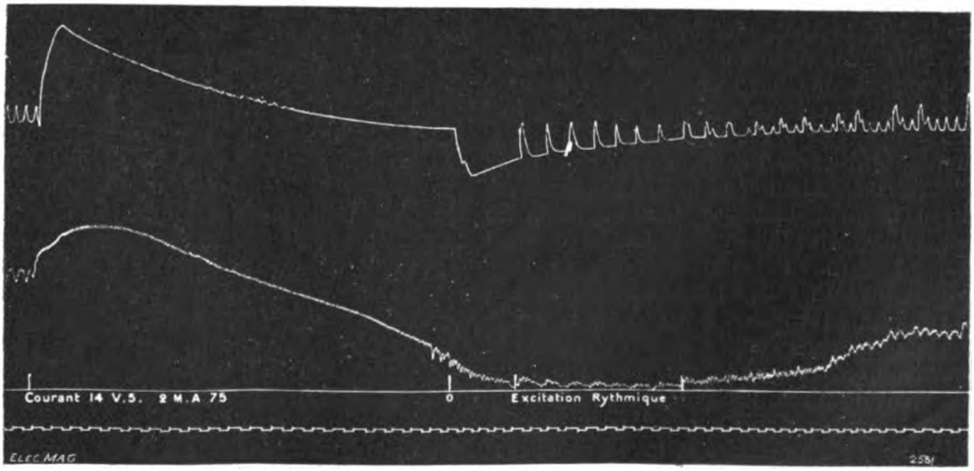


FIG. 3.

tion and (in the lower part), the curve of blood pressure.

Beginning from the left the short initial portions are characteristic of the normal stage before the electrocuting current is applied, each indentation corresponding to a complete inspiration and expiration.

As soon as the electrocuting current is completed a violent respiration (shown by a sudden rise in the curve) takes place, after which respiration ceases entirely. The convulsions to which the animal is subjected likewise disappear after a few seconds, and the animal is lifeless not only as to its outward appearance but as well according to the records of the apparatus registering respiration and cardiac beatings; the blood pressure drops rapidly as in the case of the natural extinction of life.

The right-hand halves of the curve are representative of the result when current impulses were allowed to act on the body of the animal. After a number of artificial respiratory motions (interrupted by short pauses made to watch the effect of the process) spontaneous respiration finally commences, and after one or two minutes the animal is definitely restored to life. Though its body seems to be temporarily affected to some degree by this trying experiment, it can be submitted to it over and over again without suffering any apparent harm.

The experiments made by Dr. Robinovitch strikingly illustrate the mode of death in death from electric shock. Respiration is suspended while the heart beats still continue to be recorded. In a series of experiments on electrocution the heart continued to beat after death, and even after the chest had been cut open and the heart laid bare. In one case the heart continued to beat for over half an hour after the autopsy, but certainly these beats were *a vide*, the left auricle and ventricle being empty of blood.

Electrocuted animals have in many cases been brought back to life by rhythmic excitations with the same potential that had caused death. It is obviously of the highest importance that these applications should be instituted without great delay after the opening of the circuit. In other cases the current used to resuscitate the animal was different from that used for electrocuting.

As regards a possible practical utilization of these striking results it may be said that in cases of accidental elocution or shocks with electric currents of a potential of up to 2000 volts, it would seem feasible to restore the victim to life by the aid of current impulses of a rhythm corresponding to that of respiration. If the Leduc interrupter be not available, an ordinary small mercury interrupter could be used in its place to produce the intermittence of the current. The point of importance obviously is that this treatment should be applied as promptly as possible. The method is particularly applicable in places where direct current is available; in other places the alternating current must first be changed to direct current.

Another and perhaps more valuable application of the process would be to restore persons that have succumbed from syncope during chloroform or ether anæsthesia. Though a careful examination of the condition of the heart is made by any conscientious physician before chloroform or ether is applied, cases of death under the anæsthetic are still unfortunately not unknown. By preparing everything for the application of electric impulses before the operation is begun, the life of the patient may be warranted in nearly all cases.

As regards the theoretical interest of these experiments they may be said to show that the extinction of life is quite a gradual process, and that the physiological phases of it may, by a convenient treatment, still be remedied. Death would thus seem to be definite only when chemical alterations in the body have taken place — *Western Elect.*

Wireless Telephony.

An informal talk on wireless telephony by Dr. Lee DeForest at the meeting of the New York Electrical Society on Nov. 20th, of which an account appeared in the *Electrical World*, Nov. 30th, proved to be a most interesting and instructive lecture. Dr. DeForest, in explaining the fundamental difference between wireless telegraphy and wireless telephony as practised to-day, stated that in telegraphy use is made of waves of steadily decreasing amplitude obtained from a spark-discharge for periods corresponding to the signals of the Morse code, while in telephony the waves are of constant frequency steadily maintained, only the amplitude being varied to correspond to the frequency of the voice tones. The "sustained" oscillations have a frequency so high that not only is the ear unable to detect them, but it is probable that the telephone receiver diaphragm cannot follow them; the frequency is never less than 20,000 cycles per second, and it may reach a value of 500,000 per second. By adjusting the "natural period" of the receiving circuits, the equipment may be "tuned" to respond to the transmitting circuit having the corresponding period of "sustained" oscillations.

To the labours of Duddell can be attributed the knowledge of the fact that oscillations are produced in a circuit, containing a condenser and an induction coil in series, shunted across a direct-current arc lamp. Poulsen showed that sustained frequencies as high as 1,000,000 cycles per second may be obtained by operating the arc in an atmosphere of hydrogen. It has been found that high sustained frequencies can be obtained by using compressed air around the arc, by keeping the electrodes cool artificially, or by placing the arc in the flame of an alcohol lamp. The last method is the one most easily applied, and is the one adopted by Dr. DeForest.

No satisfactory explanation has yet been offered for the production of the sustained oscillations, although the necessary conditions are well known. Thus the resistance-current characteristic of the arc is the one feature upon which the existence of the phenomenon depends. Moreover, the "pinch" phenomenon as discovered by Hering and further investigated by Northrup, probably plays an important part in the production of the oscillations.

Dr. DeForest stated that many types of receivers are suitable for wireless telephone work. In fact, any of the self-restoring wireless telegraph receivers may be used. The crude carbon block and steel needle device is usable, but the "articulation" with it is poor; the carborundum receiver is quite good, and the electrolytic is excellent. However, the Audion receiver, especially in its latest form in which the antenna is joined to an isolated grid interposed between a tantalum filament and a platinum wing, gives perfect "articulation." The speaker mentioned also the type of detector employing a gas flame for maintaining the medium separating the electrodes in ionic activity, which gives promise of excellent results in long distance wireless telegraphy. At the present time the use of the microphone transmitter limits the talking range to less than twenty-five miles, but doubtless by the use of a suitable substitute for the microphone the range will be increased enormously.

Although "damped oscillations" are now commonly used in wireless telegraph communications, the excellent results obtained with "sustained oscillations" in the incidental calling telegraph signals, as used in wireless telegraphy, point to the abandonment of the spark method of producing damped oscillations in favour of some method of producing sustained oscillations. In the present telephone calling system the antenna circuit at the transmitting station is interrupted periodically by a "buzzer" device operated by a "chopper" telegraph key, and the interruptions are recorded as a loud hum in the telephone receiver.

The Berjonneau System of Picture Transmission.

The Paris correspondent of our contemporary, *Electrical Engineering*, reports on still another system of electric picture transmission. It is said that this new method combines advantages of the Korn and Belin systems, both of which were described in the last number of THE ELECTRICAL MAGAZINE. The advantages claimed are: Small size of apparatus and greater robustness of mechanism; the use of the same apparatus for transmission and receiving; the possibility of working over the longest land lines or submarine cables, as the only line current is the very small amount required to actuate relays; and, finally, the possibility of wireless transmission. First of all, a copper relief similar to a half-tone block is made of the original picture in the form of a cylinder. This is mounted on a travelling revolving drum with a feed of 1 6mm. per revolution. A platinum point is employed, to make contact with the raised portions of the cylinder surface, and currents depending in duration on their size, but of constant strength, are thus sent into the line.

In the receiving apparatus a sensitized film is mounted on a similar cylinder, and a ray of light passing through a very small aperture is caused to fall on it as it rotates. A diminutive shutter, actuated by an electromagnet, controls the incidence of the ray according to the current received. On development, therefore, a reproduction of the original photograph is formed in fine lines 1/6 mm. apart. It will be seen that

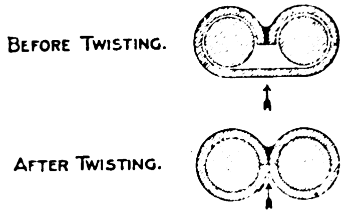


Fig. 1.

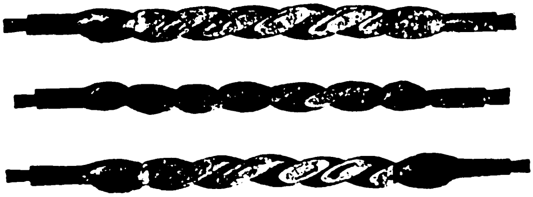


Fig. 2.

the strength of the current does not enter into the question, so that the whole of the working can be done by relays either over a telegraph wire or by "wireless" methods. The main point of importance is the accurate synchronism of the cylinders; but no information was forthcoming as to how this is obtained.

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Self-welding Wire Joint.

THE method of jointing illustrated on the following page is due to F. B. Cook, who claims that by this he has succeeded in perfecting a wire joint for splicing both iron and copper wires which is mechanically and electrically perfect. The construction of the sleeve or joint is in itself a simple matter, but its success is declared to be due to the peculiar design and the care used in its manufacture.

Referring to Fig. 1, it will be noted that one side is flat and the other is formed to fit the wires. In twisting, the flat side is drawn up into the recess between the wires and meets the upper or formed side, stretching the metal around the wires so tightly as to close up completely any space and make a perfect cold weld between the metal in the joint and the wire. It is only necessary to use the ordinary splicing tools, and the mere act of twisting the joint makes a connection that is air and moisture proof —the ideal electrical splice.

The early method of making a splice was to twist the wires together and solder the joint. After a time this method was replaced to a certain extent by inserting the wire in a double-tube sleeve and twisting the sleeve and wires together. This latter method gave moderate satisfaction in splicing copper wires, but in splicing iron wire many of the large users decided to return to the old manner of twisting and soldering, even though more expensive than the sleeve, their reason being that they could not depend upon the joint made with the new sleeve. Moisture penetrated, setting up corrosion, causing high resistance, and the joint thus made was weak. Having all these faults in mind, the inventor so constructed his sleeve as to retain the strength and other desirable features of the twisted and soldered splice and produce a sleeve with maximum strength and efficiency combined with minimum labour in application. A comparison of this joint with other types is shown by Fig. 2, in which the top illustration is a Cook No. 10 joint with one No. 10 and one No. 12 wire, and the next two are other No. 10 joints made up under the same conditions. This illustration is a reproduction of a photograph which has not been retouched. The upper portion of each sleeve or joint was filed away to show the interior of the joint. This illustration also shows that the Cook sleeve may be used as a combination joint with success, which feature is of considerable value, as it means less variety of sizes in stock for the consumer.

The strength of the new joint has been demonstrated, but some facts may be of interest. The joint is positively stronger than the wire. It will stand several twists in addition to the three and a half twists used in common practice, without fracturing, and, in fact, it can almost be tied into a knot.

It is announced that the Western Union Telegraph Company has adopted this joint after exhaustive tests, and have placed an initial order for 500,000. Amongst other recent orders are one from the Australian Government and one from Japan, demonstrating that the Cook joint is used on telegraph, electric-light and power circuits with satisfaction, as well as in telephone construction.

CANADA

and its

ELECTRICAL & GENERAL ENGINEERING TRADE WITH GREAT BRITAIN.

A GENERAL SURVEY OF CANADA FROM THE ENGINEER'S POINT OF VIEW.

THERE is no need to dilate upon the phenomenal development of Canada—to quote blue book statistics, nor to review the plethora of enthusiastic "literature" distributed broadcast by the emigration people telling always of the immensity of the newest Eldorado, and the fortunes which await each and everyone of us there—the general fact of Canada being possessed of the very greatest potentialities for money-making is universally accepted. For the benefit of the British manufacturer and the Canadian reader we have set ourselves the task of indicating to some extent the ways and means which exist for bringing the United Kingdom and her nearest colonial daughter into closer commercial touch, having particular reference to electrical and general engineering manufactures. That there is much good to be done in this way is evident from the cordial manner in which our manufacturing friends have entered into our scheme, and we are pleased not only to be able to record the personal gratification this support affords us, but also to have this confirmation that the British manufacturer is very keenly alive to, and anxious to meet, the demands of Canada.

The Dominion is in very fact a virgin country, richly blessed with agricultural, mineral and animal wealth, and abounding in forest lands, and in rivers both navigable and of high falls; coupled with these natural gifts is the essential of all—a climate which, rigorous though it may be in the far interior and north, is still entirely healthy and suited to the British temperament. Need we wonder therefore at the great activity of Canada.

The outstanding feature of Canada's progress is undoubtedly the systematic control under which its development has been worked. It has always been entirely British in its methods, hopes and aspirations since it evolved from its earliest settlement days into a definite country. And to-day it is more than ever a Britain beyond the sea; its government and laws, its municipalities and boroughs, from parliament house to parlour, the same broad principles and sentiments govern and prevail as in the Mother Country. The commercial engineer of the British firm finds in Canada just that ground which suits him best: he is welcomed as from home, and he is very much wanted. In the course of a conversation with Mr. W. L. Griffith, the able and genial secretary of the High Commissioner for Canada, the writer had recent confirmation of the distinctly favourable attitude of Canada towards the British manufacturer and his goods.

Experience proves that where this country is in competition with the foreigner for Canadian orders, the most frequent cause of the settlement away from the British house is on the score of delivery. This is a point which cannot be emphasized too strongly. It would seem that—and particularly for the smaller classes of machinery and supplies—a Canadian stock or even a branch works is essential for the British manufacturer to maintain a continuous profitable business in the Dominion. Many of our leading firms realized this point long ago; in the electrical industry we find immediate examples in the Westinghouse (the Canadian Westinghouse Company, Ltd.) and Thomson-Houston (Canadian General

Electric Company, Ltd.) organizations—in both cases very extensive works are in operation in Canada, producing a complete series of these well-known products from the largest-sized generating units down to the smallest "accessory." There are several other examples of such works colonization, particularly where the specialities dealt with are agricultural machinery and implements and the general grades of hardware.

From time to time we receive enquiries from readers as to the advisability of the formation of branch factories in Canada. We can here state definitely that in the great majority of cases the establishment of such branches will prove highly successful.

It is difficult to the stay-at-home Englishman to realize the immense rate at which civilization and urban conditions are advancing in Canada; perhaps the quickest way to grasp the real progress made is to compare an up-to-date map of the country with one of ten or even five years ago. One is inclined to regret the pains of having mastered geography at school—there is so much regarding this Dominion of Canada to be unlearned. In the year 1871 Canada's imports aggregated in value some nineteen and a half million pounds, in 1905 the corresponding figure stood at nearly fifty-four millions. The figures of export for the same periods were roundly fifteen millions and forty-two millions respectively. Having introduced statistical figures it will, perhaps, not be out of place to continue with some general facts relating to the resources and activity of Canada as true at the close of the year 1905. Railways, steam and electric: 21,000 miles completed and 5000 miles under construction. Factories: 15,000 in number, employing 450,000 hands and turning out to the annual estimated value of £123,203,285. The capital invested in the mineral enterprises amounted to £21,355,236; the value of production of gold being upwards of £3,300,000, and of coal about 3,000,000; upwards of one million pounds value each of copper and nickel were also produced. Yet with all this wealth it is important to remember that the area of Canada is about one-third that of the entire British Empire; that in the year under notice it had a population of 5,600,000, or only about 1.5 persons per square mile.

Returning now to the subject of Canadian branch works, we see that the great progress made is but the very small beginning in a vast territory in the further making and maintenance of which an unlimited scope for labour exists for many generations to come. In the course of correspondence with manufacturers we have noticed not infrequently the expressed disposition to postpone active work in Canada "until the country is further developed and offers a more extended market." Surely this is an unreasonable attitude to adopt, and the more one considers the matter in detail the more impossible does it become to justify it.

The towns springing up on every hand are not mere settlements or camps—they are permanent institutions for which nothing will do which is less than the very best and latest in equipment and arrangement. The most advanced practice in civil and municipal engineering is followed. In this systematic building up of towns and cities there is brought to bear, from the beginning, a full sense of the financial or business side of municipal management. In the pursuance of this policy it is a fact that rising Canadian towns welcome the advent of factories into their midst; and, lest any misapprehension as to motive should arise, let us hasten to say that they offer substantial inducements to the manufacturer in the shape of remission of taxes, or cheap land, or even financial support to the contemplated works venture. The fact is that these manufactories are wanted by the country for the sake of their output; the importing of goods, with the consequent delay and high ruling prices, hampers the Canadian. Factories will continue to be started at an ever-increasing rate, and the municipal owners know the immense value of labour-employing concerns to any surrounding or adjacent township: hence this competition for the manufacturer's favour.

General transport facilities by railroad, tramroad and canal already exist in a very complete form, and the active work of extending this essential proceeds without abatement. Capital is readily found for the furtherance of personal enterprise in the manufacturing field; there are partnerships entered into regularly between the experienced British manufacturing man and his moneyed colonial brother. In short, there is everything to be said in favour of the British firm establishing a Canadian works centre. Moreover, as will have been gathered, there is also great certainty in the successful outcome of individual enterprise in works ownership. This latter phase is one to which the young engineers of this country should give the closest consideration; Canada undoubtedly offers much to the well-skilled engineer, and in this trade, as in many others, it gives a full answer to the oft-asked question, "What shall we do with our boys?"

The work of the daily press in connection with Canada should not be taken in a too literal sense. There are letters of adulation and of condemnation, but what else could be expected—there is nothing worth while accomplished, even in Canada, without well-directed continuous effort. We have received letters from British manufacturers who deplore the close proximity of the United States, and accept this state as an insurmountable barrier to their entry into the Canadian market; to these we can only reply that it would be worth their while to try properly on the spot and satisfy themselves as to what is the real extent of the U.S.A. competition in Canada. They will undoubtedly get a pleasant surprise; as said, there is the importance of quick delivery: let our manufacturers meet that point and they are sure of success following their enterprise.

As this number of THE ELECTRICAL MAGAZINE goes to press there is a continual stream of articles appearing in the daily papers based upon the fact that the present year marks the dawn of the third century for British America. The reiteration of Imperial sentiment abounds in these articles; day by day Canada and this country draw closer together in recalling the struggle of common ancestors, the heroism of Wolfe and Montcalm. Such gems of history are too easily lost sight of in the workaday world, but they have an immeasurable effect upon the trend of trade. When Canada proposes that the battlefield on which Britain and Canada became united be acquired by the Dominion Government to serve as a memorial of that great fact of unity in perpetuity, there is an instantaneous approval and tangible response throughout the two countries. Here is sentiment merely—yes, but there is no bigger power in business than sentiment, whether the point at issue be individual or national.

It might be thought that in this article we are bent on "wakening" Britain. If there be some sleepy ones who after reading feel encouraged to look around the Canadian field, all the better for them. In this connection we may again quote Mr. W. L. Griffith, who has strong opinions as to the character of the British manufacturer, and he speaks also as for the Canadian. "It is all nonsense," says Mr. Griffith, "to talk of the decadence of British enterprise in trade. On the reverse, this country is indeed flourishing as one in the full strength of a perfect maturity. Canada, as a rising country, young and energetic, knows and feels that this is so; throughout the Dominion the name of Britain is taken as the guarantee of best; her example is followed, and her manufactured products are sought after whenever practicable. The Canadian has the fullest appreciation of British trade methods and honesty of purpose and material."

It may be said that Canada is requiring manufactured goods of every class, size, and material. In engineering there is trade to be done in every one of the innumerable towns growing up along the thousands of miles of railroad, in the chief centres of the agricultural lands of Ontario, Saskatchewan, and Alberta, in the mines and on the rivers of British Columbia, in the collieries and iron-works districts of New Brunswick in the East and the Rocky Mountains of the West, in the flourishing industrial area of Ontario, and in the leading cities of the Eastern Provinces.

A study of the industrial map of Canada shows that the leading industries are more or less centred in particular districts. The State of Ontario, bordering on the Great St. Lawrence and holding the immense natural asset of Niagara Falls, is literally threaded also with a network of rivers and streams from a large number of which hydraulic power can be readily drawn. It is to this province, with its prolific natural power supplies, that the manufacturer should turn when selecting a works site. It is there that the greatest municipal development is taking place; it provides a market at once and will undoubtedly be the chief industrial centre of Canada for all time. The electrical manufacturer and the power engineer, the maker of machine tools and the mechanical engineer, are particularly called for in this district; for the establishment of works, for stores, for branch offices, or for the individual engineer "striking out" for himself, this is the territory to settle upon in the majority of cases.

As to the question of raw materials for engineering manufacture, these are to be found in abundance. It is reported that untold mineral wealth exists throughout practically the whole country. In and around the more populated districts the mining of coal and metalliferous ores is carried on to a remarkably great extent; indeed the mining industry has already become one of the most important in the Dominion. Referring to the map of Canada we find at the eastern door of the country a vast coal-yielding district spread at the mouth of the great St. Lawrence. The coalfield of New Brunswick and Nova Scotia, with its main distributing centre at Sydney on Cape Breton Island, is one of the busiest and most productive of the American continent. A remarkable feature is that the bulk of the coal gained here is exported to the adjacent New England States of the U.S.A.; whilst on the other hand the principal coal supply for the great industrial area of Ontario, which nestles on the northern shores of the great lakes, is imported duty free over the lakes from the Pennsylvania coalfield. It is singular and yet typical of the immensity of the country that with the exception of the close fringe of towns outlining the course of the St. Lawrence and the eastern portion of the Grand Trunk Railway, there has as yet been little done in the way of tapping the mineral stores of the country. To pass only about 200 miles or so to the north of this fringe of towns is to enter the "Wild West," as it is termed; and this sparsely settled territory, where the bear and beaver are still found, is not an unknown land: it has been well surveyed and it is generally rich in mineral wealth. The district known as Ungava, to the north of Quebec Province and east of St. James's Bay, is a rough rocky country which is practically one huge mine wherein iron, gold, silver, and copper occur in endless quantities and generally in a form and position easy to work. Nearer to the cities, and indeed alongside them, on the north of Lakes Superior and Huron, are very rich mines being worked for iron, copper, silver, zinc, cobalt, and nickel. It is in this metalliferous belt that the town of Cobalt, of which we have heard so much lately in connection with mining finance, is situated. A little north of this mineral wealth occurs a coalfield as yet undeveloped, but which is sure to be tapped in the very near future. Passing West there is a great coalfield in the south of the farming provinces of Manitoba and Saskatchewan, and this extends away into the Rocky Mountains in Alberta, where is the largest coal-yielding district of the Colony. Everybody has heard of the Crow's Nest Pass in the Rocky Mountains, of Calgary and Edmonton; they are the centres of Canada's mining interests. Not only is coal worked here in very large quantities, but gold, silver, platinum, lead, and zinc are found in profusion. The coalfields are also tapped for petroleum and natural gas. The metalliferous deposits pass right through the Rocky Mountains and are continued and worked to the most western point—the seaboard of Vancouver Island and British Columbia. The Klondike, with its goldfields, situated in the icy extreme north-west corner of the country, is known to all. There are many other of the out-of-the-way districts of Canada which will in all probability outdo even the Klondike when the gold rush sets in, for the king of metals is known to exist in many of the, as yet, desolate regions of the far north.

CANADIAN POSSIBILITIES.

PERCY A. HURD.

THE nineteenth century belonged to the United States; the twentieth century belongs to Canada. This dictum owes its origin to Sir Wilfrid Laurier, and it has become a household word in trans-Atlantic talk. Make what allowances you please for the optimism of a young community, and there will remain a solid substratum of probability in the prediction, and it carries a message of supreme importance for all British manufacturers, not least those concerned in the electrical trades.

Once "Isolated and Stagnant."

Lest we who are Canadians and Anglo-Canadians should be thought to take too rosy a view of Canadian possibilities, let us seek the opinion of Canada's greatest rival, whose territory borders the whole length of her own on the North American Continent. For a generation, in fact ever since the abrogation of the Elgin reciprocity treaty in 1866, it has been the habit of most citizens of the United States to regard Canada as a mere fringe along the northern boundary of the United States—a territory whose people were generally unprogressive, and whose lasting prosperity could only be secured by inclusion in the Republic. Isolated and semi-stagnant, Canada might, it was thought, be ignored as a material factor in North American industrial life, and for fifty years, before and since confederation, United States policy has been designed more or less to force Canada to an acknowledgment of her dependence and accept the political embraces of her powerful neighbour. But through it all Canada has gone her own way and thriven, and to-day she stands, in the words of Mr. Root, the Secretary of State in the United States Government, a "great nation."

A Rival of the United States.

One might fill many columns with authoritative United States declarations supporting the epithet which Mr. Root has now attached to Canada. Let it suffice to quote the latest tribute which appears in the columns of the *Philadelphia Bulletin*, expressive as it is of a conviction which is now becoming fairly general among thinking people in the United States :—

> "It is true that with an area substantially equal to our own, Canada has a population of only about seven millions, or less than of Pennsylvania. But it is likewise true that her foreign trade *per capita* far exceeds that of the United States, and is rapidly developing into a source of permanent prosperity, unless all indications are at fault. A new commercial treaty with France, designed to increase the interchange of goods between the two countries, is now before the Parliament at Ottawa; and it is announced that other agreements with different nations will be formed for the same purpose. In the meantime it is pointed out that the revenues of the Canadian Government have more than doubled in the last ten years, amounting now approximately to one hundred million dollars annually ; while the sums invested by that Government in railroads, canals, harbour and river improvements, and other betterments of a permanent character, are not far from four hundred millions. When it is recalled that the number of people directly concerned in these expenditures is less than one-twelfth of the number of the inhabitants of the United States, it is evident that the Canadians are not deficient in energy and 'hustle,' taken as a whole. If they keep on at their present rate of progress for another decade, 1917 will see a nation of no mean proportions, either as regards accumulative wealth or industrial and trade prowess, just on the other side of the imaginary line which marks the boundaries of our own country to the northward."

We know it to be the conviction of Lord Strathcona that before this century has closed Canada will possess a population not less than that of the United States of to-day.

"White Coal."

In the space at my disposal it is impossible to attempt anything like an adequate survey of the enormous resources which United States authorities thus credit to Canada, and which must give Canada a predominant place among the industrial nations of the world. An indication may, however, be given if we take one of her national assets—her "white coal," as the abundant water power of almost every section of the Dominion has been aptly termed. There is no means of measuring the water-power resources of the Dominion of Canada as a whole, but in one of her nine provinces, namely Ontario, it has been carefully surveyed by a Royal Commission. This body, the Hydro-Electric Commission, reports that there is in this one section of the Dominion water power capable of generating no less than 3,500,000h.p., and unofficial experts tell us that this figure probably represents not more than half of Ontario's resources in this respect, as they will ultimately be disclosed. Less than 300,000h.p. has so far been utilized, so that there awaits the enterprising capitalist and worker no less than 3,000,000 h.p. to drive the machinery of lumber and pulp mills and of the mines yet to be developed in the Northern part of this one Canadian province. To produce this power from coal would, it has been estimated, in Canada, require an annual expenditure of over £20,000,000 sterling.

Openings for Great Industries.

On the Canadian side of the river Niagara alone 300,000h.p. is being developed, and Toronto is lighted and drives her tramcars with power conveyed from the great falls. One of the deputation of British journalists recently in Canada as the guests of the Ontario Government points out truly enough that what is being done to develop the water-power of Niagara is also being carried on at the Sault Ste. Marie, between Lake Superior and Lake Huron, at Sturgeon Falls in Lake Nipissing, at Spanish River, and scores of other places in Ontario, where the waterfalls are being harnessed in the service of mankind. At the "Soo," as the Sault Ste. Marie is locally termed, only a tithe of the available water is yet utilized, but enough is at work to drive immense pulp and lumber mills and furnish power for the great plant of the Algoma steel works, where the first steel rail made in Canada was rolled three years ago. The "Soo" is one of the most promising districts in America for the development of great industries. It has unlimited water-power at its very doors, and its geographical situation is unrivalled. All the shipping on the great lakes from the vast wheat country to the North-West, and from the mineral-bearing country round Lake Superior, passes through it. Three canals, all toll-free, permit the passage of vessels from Lake Superior to Lake Huron. The tonnage passing through these canals is nearly treble that which passes through the Suez canal. And what is happening at the "Soo" and at Niagara is happening all over Ontario, and the openings for enterprise are many. We are told how small places, little more than camps, have electric light and power. Mining machinery, saw mills and pulp mills are run by electricity in seemingly out-of-the-way places. As the timber and pulp-making concessions are taken up and the mineral deposits are developed, the demand for power will increase, to say nothing of the requirements occasioned by the expansion of existing and the springing up of new manufacturing centres.

Enter United States Capital and Brain.

But great as is the attractiveness held out to the enterprising by the resources of Canada, it has to be confessed that outside the Dominion the chief benefit has gone not to Canada's motherland, but to the United States. Propinquity counts for much. It is so infinitely easier to cater for a market only a few hours away, often within reach even of the telephone, than for one which is on the other side of the Atlantic Ocean. United States capital has flowed freely into Canada for the development of the electrical industry, and United States capital and United States brain have been largely responsible for the difficult position in which British manufacturers and capitalists find themselves when catering for the Canadian market. One of their greatest difficulties is the Canadian adoption of United States standards and specifications.

The Market for Electrical Apparatus.

Take electrical apparatus as an illustration of the present predominance of the United States in the Canadian electrical import trade, and one finds that the Canadian importations from the United States were in 1906 of the value of £487,000. This total compares with £17,000 only as the value of imports from the United Kingdom and £3,000 from Germany. Yet there is a full duty of 25 per cent. against United States imports, and British manufacturers have the benefit of a preference of 33⅓ per cent. A similar duty and a similar preference operate in the case of electrical motors and dynamos; yet the United States importations into Canada were in 1906 of the value of £202,000. Taking United States imports into Canada over a series of years it is suggestive to note their growth. (See table below.)

Copper Wire.

The trade in insulated copper wire for telephone and electrical work may be taken as another indication of United States predominance in Canadian electrical development. The imports in 1906 from all countries were of the value of about £71,000, and of this

CANADIAN IMPORTS FROM THE UNITED STATES.

		1902.	1903.	1904.	1905.	1906.
		£	£	£	£	£
Electrical apparatus (including batteries and telegraph and telephone instruments		195,000	227,000	371,000	377,000	487,000
Electrical motors and dynamos		68,000	86,000	95,000	169,000	202,000
Totals	Dutiable..	227,000	325,000	483,000	558,000	697,000
	Free	—	—	—	5,000	14,000

total the imports from the United States were of the value of no less than £64,000, despite the fact that the Canadian import duty is 30 per cent., with a preference of 33⅓ per cent. to United Kingdom manufacturers.

"Canada for Canadians."

The main object of the Canadian tariff is, of course, to stimulate Canadian industry, and it is a cardinal principle of Canadian policy, no matter what party is in power at Ottawa, that Canada shall make whatever she can for herself within reasonable limits, and always remembering the interests of the general consumer. Aided by the Canadian tariff and aided also, of course, by the enormous natural advantages of Canada, the Canadian factories for the manufacture of electrical machinery and apparatus have become among the most extensive in the country. An official publication tells us that their output includes motors and dynamos of the largest capacity, as well as miscellaneous apparatus in great variety. "Canada," it is officially declared, "because of its numerous great waterfalls, presents an extending field for the installation of hydro-electric power-generating machinery, and the installation of power generating and transmission plants constitutes one of the main departments of electrical manufacturing. The field for electric lighting is rapidly increasing. Even the smallest hamlets are being provided with electric street lighting. Most modern houses of consequence in the cities and towns are fitted with electric light, and for the lighting of factories, public buildings, &c., its use is almost universal. On this account there is a growing demand for dynamos and all kinds of electric lighting appliances, and Canadian factories supply the entire trade. Electric equipment for street cars and inter-urban railways, is made exclusively, while certain firms devote special attention to the production of electrical mining machinery."

Experience of British Manufacturers.

But great as are the opportunities for the development of manufacturing in Canada itself, and undoubted as is the predominance of the United States in the Canadian import market, many British manufacturers speak with expectation of the Canadian market. In Great Britain itself, where they have no tariff benefit, British manufacturers have in many directions found themselves equal to the keenest United States competition, and with the aid of the preference given them in the Canadian market they see no reason why they should not develop a substantial Canadian trade. The preference has in many cases sufficed to enable British manufacturers to sell the bigger machinery in Canada as against the United States. Thanks to the preferential tariff discrimination in their favour, a large British house was recently able to secure the contract for the rolling stock for an inter-urban Canadian line, and it is realized that the Canadian demand for electrical plant is extending so rapidly that British manufacturers should, with reasonable enterprise, secure a much larger Canadian trade. With this in view many would greatly welcome a reciprocal arrangement with Canada, under which the family idea would animate the policy of the Mother Country as well as the Colonies, and British manufacturers would secure in the Canadian market a greater tariff margin in their competition with the United States than is secured under the one-sided preference now in operation.

Reciprocal Preference.

Even a cursory study of the structure of the new Canadian tariff indicates the manner in which such a reciprocal arrangement may be brought into existence. There is no responsible political party in Canada which would favour the exposure of the Canadian electrical industry to open competition from abroad; that is to say, it is useless to expect, for some years at all events, the free admission of British electrical goods into Canada. But it is the policy of all Canadian parties to give British manufacturers the greatest possible advantage over the manufacturers of the United States, Germany, and other countries, and a glance at the foregoing figures illustrates how large is the amount of dutiable imports upon which a larger preference may be secured without injury to the Canadian industry. There is moreover that important new feature of the Canadian tariff system, the Empire Free List, and there are commodities now admitted free from all countries which in return for concessions Canadian ministers would be prepared to transfer from the General Free List to the Empire Free List, making them dutiable when coming from foreign countries, and free when coming from other parts of the British Empire.

Thus in a sentence it would seem that while there are undoubted difficulties in the Canadian market for British electrical manufacturers, there is even to-day a substantial opening for British enterprise, and Canada's certain and rapid development in the near future must greatly enlarge the opportunities. It is also clear that so soon as the British people adopt the policy of Empire markets for Empire workers, and reopen the door which was "banged, bolted, and barred" at the Colonial Conference of 1907, Canada will become one of our most important and profitable trade partners.

ELECTRICAL AND GENERAL ENGINEERING MACHINERY, MATERIALS AND APPLIANCES.

Circuit Breakers.

J. G. STATTER, M.Inst.E.E.

UNIVERSAL acceptance of the automatic circuit breaker has been delayed by its liability to trip on the happening of a trivial short on a sub-circuit already protected by a sub-fuse or circuit breaker. But now that a really satisfactory partner has been found in the shape of a time lag, circuit breakers are rapidly replacing fuses for the protection of electrical circuits, in both central station and industrial applications of electric power and lighting.

At the present time, the true functions of a circuit breaker are not generally well understood, and it is customary for the purchaser to rely chiefly on the name of a maker, or on the name acquired by a particular circuit breaker, than to consider the intrinsic merits of the instrument itself. Consulting engineers, in current specifications for circuit breakers, as a rule content themselves by specifying what is required to be done, and in some cases certain names, either of firms or types of breakers, are mentioned as being suitable for the work proposed.

Circuit breakers may be roughly classified as follows:—

Alternating Current.

(1) Oil switches with automatic tripping gear acting on an excess current, and with or without time lags.

(2) Air-break switches for low voltages, such as those commonly employed for industrial motors, say 400 volts and thereabouts.

(3) Reverse - current circuit breakers, with or without time lags.

(4) No-voltage circuit breakers.

Oil-break switches with auto trip gear are also employed for low voltage, and owing to the simplicity with which such switches can be constructed they are suitable equally with air-break switches.

Direct Current.

For direct current the principle of damping out the arc by means of oil cannot be employed owing to the semi-explosive action which takes place when a d.c. current is interrupted under the surface of oil.

Circuit breakers therefore for d.c. work are divided into the following classes:—

(1) All air-break circuit breakers with or without time lags.

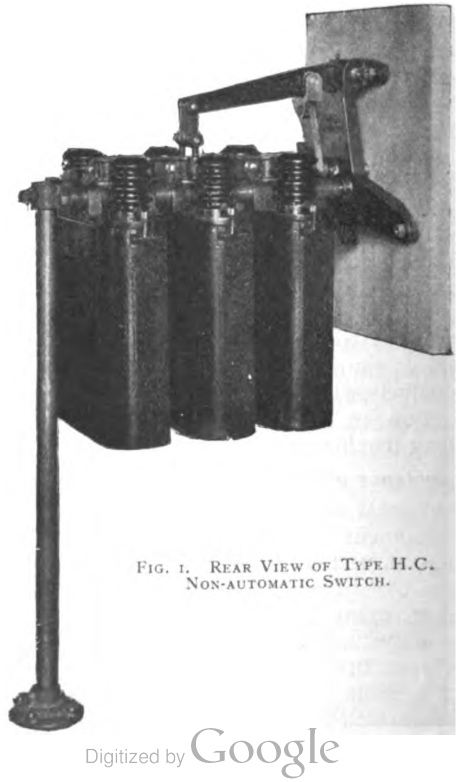


FIG. 1. REAR VIEW OF TYPE H.C. NON-AUTOMATIC SWITCH.

(2) As above with magnetic blow-out.

(3) Reverse-current circuit breakers.

(4) No-voltage and no-load circuit breakers.

Oil switches with excess auto trip gear should comply with the following requirements. The handle should be a free one, that is to say, it should be impossible to hold the switch in when a current exceeding that for which it is set is flowing. The operating mechanism for the smaller switches should be arranged so that it can be placed on the front of the panel, whereas the tanks of the oil switch itself are fitted at the back of the panel. For two or three phase work it is better to have subdivided tanks for all switches controlling more than 100h.p.; such a switch is shown in Figs. 1 and 2, where, however, the operating mechanism is not clearly illustrated. It will be seen that in the switch illustrated, which is for three-phase, each pole is contained in a separate tank. The tanks themselves should preferably be constructed of insulating material throughout, and when subdivided as shown they are easy to handle on switches of the class under consideration, namely, those for moderate-sized plants.

The best form of trip gear is that which consists of a striking coil energized from one or more phases as required, and operated by means of a current transformer. This trip coil should in turn be controlled by a time lag, either directly attached or in the relay form, mounted in any convenient position on the switchboard. The induction form of time-limit relay is fairly well known, and gives the requisite curve of time lag needed. It is, however, somewhat delicate, and a more hardy form has been recently put upon the market; this latter has the advantage of giving ample operating power just at the moment when such is required, viz., at the moment of acting to trip.

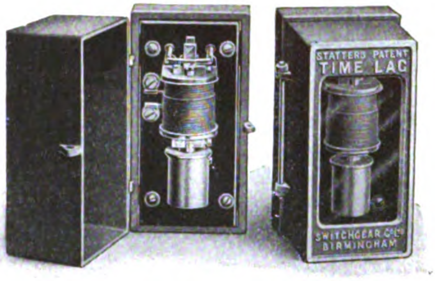


FIG. 3. THE STATTER TIME LAG.

As this instrument is not very well known it is illustrated in Fig. 3. It consists of a coil energized from a current transformer, and having an armature capable of being set to operate at any required current. The movement of the plunger is controlled by a sucker, having a plane under surface which rests upon an approximately truly surfaced base. The surface tension causes the sucker to adhere to its base, and the action is intensified by the application of a thin layer of suitable liquid to the surfaces. Separation of such surfaces follows a "law curve." The curve is of hyperbolic character, and lends itself extremely well for the purpose required.

Fig. 4 shows a curve given by such an appliance, when the force used to separate the discs is that of the attraction of a magnet to its armature.

The curve of separation of the discs themselves if referred to a pull in ounces is a fixed one, that is to say, its character cannot be changed. At a certain given pull the discs can be separated instantly, whereas a very small pull, if continued for a sufficiently long time,

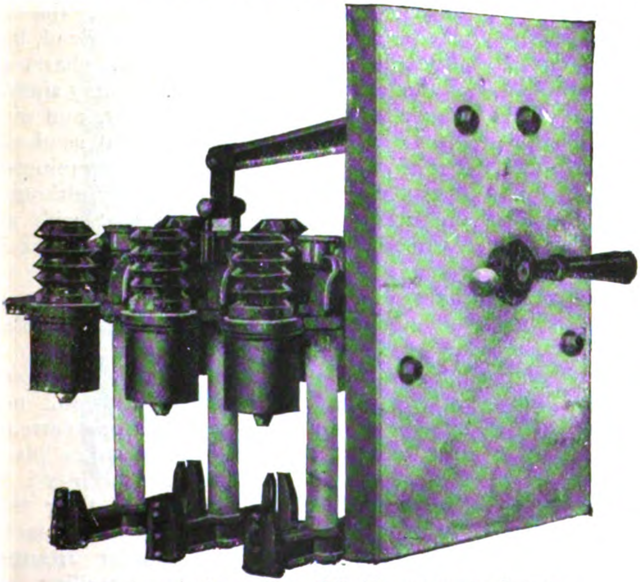


FIG. 2. 15,000 VOLT, TYPE H.C. NON-AUTOMATIC SWITCH, WITH TANKS REMOVED.

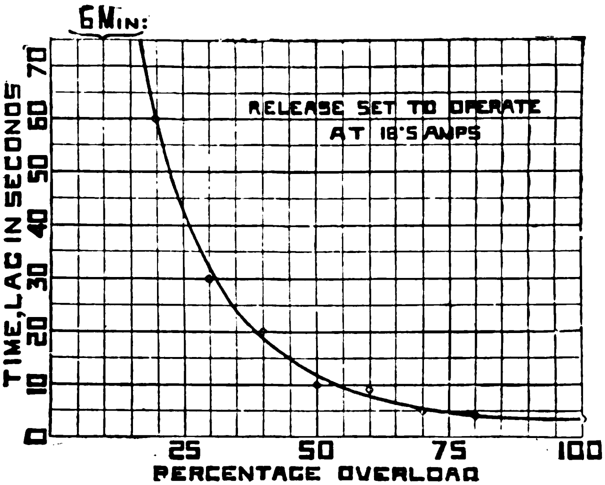


FIG. 4. CURVE OF STATTER TIME LAG OPERATION.

will eventually separate the discs. This curve can be utilized with proper magnetic appliances either to give no lag with a short-circuit current or it can be arranged to still retain a small lag. It will be obvious that by arranging that there shall be a limit to the amount of the magnetic pull this latter condition can be attained.

Another feature which renders this appliance particularly suitable for an electric time lag is the entire absence of back-lash. Any tripping gear which depends for its action upon the shortening or lengthening of the air-gap (which is the usual method of setting trip coils for both a.c. and d.c. circuit breakers) must of necessity be controlled by a time lag having no back-lash. Any apparatus depending on bellows or dashpot action will allow the armature to rise and shorten the air-gap, and so in effect alter the setting of the apparatus, so that should the excess load pass off the apparatus may still act and trip the breaker unnecessarily.

In Fig. 4 it will be seen that the reduction in the time of lag from 75 per cent. of overload to 100 per cent. is only one second, the curve at this point and onwards being nearly parallel to the base line. This arrangement enables breakers to be set to come out in a series order, and a proper selective action to be attained.

The oil switch, fitted with time lag as above described, forms a suitable protection for feeder circuits. For generator circuits another feature is required, namely, a discriminating relay, which will trip the breaker with a reverse or motoring current of small dimensions, if the same current is persistent. Reverse-current circuit breakers for a.c. work need a time lag. It is undesirable to cut an alternator out too quickly on the passage of a motoring current, but if it persists, then the switch should act. Light air-break circuit breakers for 440 volts and thereabouts may consist of simple forms of air-break circuit breakers, the whole of the mechanism being mounted on the front of the switchboard, or enclosed in an expanded metal guard if used on separate panels for motor protection. The commonest protection hitherto used for a.c. motors is the fuse. This is a particularly unsuitable protecting device, and especially so on single-phase work. Here a large current at starting cannot be avoided, and if the fuse is capable of withstanding this current it is quite useless for protecting the motor from overload. A simple cheap circuit breaker provided with a time lag fulfils all the required conditions. The time lag, as will be seen by reference to Fig. 4, will allow a considerable time to elapse before opening the circuit with, say, a 50 per cent. overload. On the particular curve illustrated only eleven seconds would elapse before the circuit would be opened at this overload, but although it is not easy to vary the character of the operating curve, it is a very simple matter to raise or lower it bodily, and with the sucker arrangement described as above it is quite easy to get a delay of two minutes at 50 per cent. overload. Similarly, although the curve illustrated shows that with an overload of 10 per cent. six minutes' lag is given, it is quite easy to obtain 12 or 14 minutes at 10 per cent. overload. It is therefore in the hands of the motor user to set a circuit breaker provided with a time lag so that it will protect his motor against sustained overload, and will not be affected by the normal starting current. If, however, a short circuit takes place these air-break switches are arranged to give a sufficiently large pull on their trip gear to drag the discs apart with practically no time lag. A similar arrangement can be made for controlling oil switches arranged for low voltage a.c. work, but on account of the ease with which the arc is extinguished on an a.c. circuit oil switches are quite unnecessary for 400 volt work, and it is better practice, except for mining work, to employ air-break switches of single, double, or treble pole, according to the requirements of the circuit.

Direct-current circuit breakers have a somewhat heavier duty to perform than those employed to control a.c. circuits. Those employed on tramway feeders operate at frequent intervals, and are required to be capable of breaking the circuit quickly and quietly, without alarming the attendant or becoming injured themselves. Such breakers are illustrated in Figs. 5 and 6. The requirements of a circuit breaker for d.c. feeder protection are:—

(1) Great durability.
(2) Free handle action.
(3) Ready adjustment of pressure on contact.

The brush should be made of thin laminations of hard drawn copper, and pressed upon plane-faced contacts. All gripping arrangements between brush and contacts are dangerous, as they lead at times of heavy short circuit to seizure between blade and contacts, with disastrous results. The d.c. circuit breakers should be provided with three separate contacts, leaving in regular order. The main brush must leave first; next, an auxiliary contact (preferably of copper and of fairly considerable mass); and the final break must be taken by carbon contacts. Some engineers have recently expressed a preference for contacts of copper for the final break, their reason being that although copper is inferior to carbon for this purpose it is not subject to fracture, and consequently breakers which go abroad, or which are subject to hard usage, are often specified to be provided with copper contacts for the final break. It is preferable, however, to meet the requirements by arranging for ready renewal of the carbon employed for the final break. In the breaker shown in Fig. 5 this is provided for.

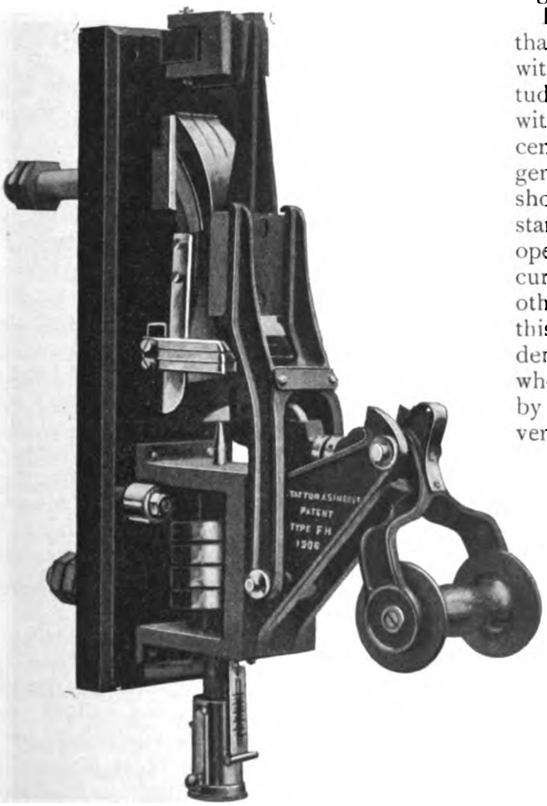


Fig. 5. Model C Circuit Breaker with Time Lag.

Reverse-current attachments must be such that certainty of operation is secured even with reverse currents of very large magnitude. Normally they are set to operate with a reverse current of only a small percentage of the full working current of the generator protected by the breaker, but should an attendant accidentally switch in a standing generator, the relay is required to operate with a sudden and very large reverse current. Many reverse-current attachments, otherwise excellent, will not comply with this condition. The sudden rush of current demagnetizes the polarized armature, even when the same is permanently magnetized by a shunt current. This reversal is prevented by the addition of a choking coil. The choking coil at the moment of reversal gives a magnetizing effect in the forward direction, and neutralizes to some extent the violent action of the reverse. This choking is of very mild description when light overloads are being dealt with, and consequently does not prevent the ready action of the relay at such currents, but when sudden reversals of large magnitude take place its action is sufficient to prevent the reversal of the polarized armature, and the relay is reliable under all conditions. In the case of reverse-current

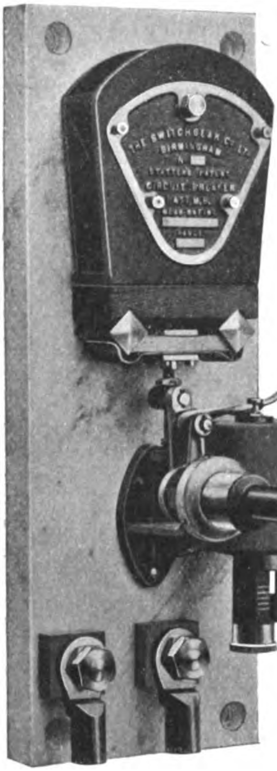


Fig. 6. Circuit Breaker with Magnetic Blow-out and Time Lag.

circuit breakers for d.c. work, a time lag is not usually required. D.C. generators are not subject to the same surging action as alternators, and it is usually better to allow a reasonable margin in the way of reverse, but to allow the relay to act instantly if this reverse is exceeded.

Fig. 6 illustrates a form of circuit breaker provided with a magnetic blow-out. The breaker is provided with the usual laminated brush, the secondary copper contacts, and final break contacts of copper situated in an intense magnetic field. The final contact is enclosed in a casing lined with non-inflammable insulating material, and the breaking of heavy short circuits takes place without any visible arcing. This breaker has also the advantage of being extremely flat. It is operated either with a handle or with a removable key, as shown in the illustration, and has a free handle movement.

Circuit breakers are, of course, usually installed on all central station switchboards, and on the switchboards of industrial supply stations, but they are equally useful both for motor protection and for the protection of service mains. In both of these applications fuses are still employed where initial economy is the first consideration, but as circuit breakers are now being manufactured in large quantities, and can be supplied at much lower rates, pairs of breakers are frequently used for the protection of service mains, and when provided with time lags form an ideal arrangement for this purpose. The breaker illustrated in Fig. 6 lends itself excellently for this application, and a pair of such breakers can be very cheaply arranged in either a cast-iron case, or still better for most purposes in a casing of expanded metal.

The key action enables the service to be placed in the charge of some person in authority, and the combination dispenses with service switches.

The author desires to express his thanks to Messrs. The Switchgear Company, Ltd., of Newhall Street, Birmingham, who have provided blocks of typical circuit-breakers for the purpose of illustrating this article.

Large Pumping Plants.

Whilst it is undoubtedly the case that British manufacturers of water-turbines are handicapped somewhat in the Canadian market for lack of much experience in the building of large units, and that the United States are in the best position in this respect, there is at the same time an immense amount of work of this description which will ultimately find its way to this country. Turbines are in constant demand for the innumerable hydro-electric schemes essential in the colony's development; and it is generally held that the home country will secure more and more of these orders. There are already many large pumping plants of British origin at work in the Dominion.

It is of interest to note that Messrs. Mather & Platt, of Manchester, have in hand at the present a number of important electric pumping plants for Canada. These include the following:

For the Montreal Water and Power Company they are to supply a three-chamber high-lift turbine pump capable of dealing with a maximum of 10,500 gallons per minute against a pressure equivalent to a head of 405ft. when running at a speed of about 465r.p.m. The pump is to be driven by a three-phase motor of 1680b.h.p. at

2200 volts 63 periods. Also for the same company Messrs. Mather & Platt are building a special high-speed pump, capable of dealing with 10,500 gallons per minute against a pressure equivalent to a head of 405ft. when running at a speed of about 1500r.p.m., driven by a Zoelly-type steam turbine of 1720b.h.p., complete with auxiliary pumps, condensing plant, &c. These two huge pumping sets form respectively the third and fourth contracts which the well-known Manchester firm has received from the Montreal Company.

Through Messrs. Drummond McCall & Co., for Edmunton, there is also under way at the Mather & Platt works a four-chamber pump, capable of dealing with 2090 gallons per minute against a pressure equivalent to 405ft. head. This direct-coupled pumping set runs at a speed of about 875r.p.m., and is driven by an alternating current motor of about 450h.p.

◆

Electric Cable-Making Machinery.

It would seem that there are several firms contemplating the establishment of electric cable factories in some of the larger cities of the Dominion. To those interested in this very promising field of manufacture some details of the processes and plant necessary will appeal with particular force. In this connection it is to be pointed out that Messrs. Johnson & Phillips occupy a unique position with regard to the manufacture of cable-making machinery in that they not only manufacture every class of machine required, but that they are also users of these machines, and have one of the most extensive outputs of insulated wires and cables of any firm in this country. The manufactures of this well-known British firm cover practically every requirement in the way of electrical plant and apparatus, and that they are well up to date in matters of design will be gathered from the following brief descriptions of those of their engineering specialities which are most likely to be in general demand for Canadian usage.

The Company's wide experience in cable-making has enabled them to make very considerable improvements in the design of cable-making machines to meet every modern requirement. It is, indeed, claimed that Messrs. Johnson & Phillips are the leading firm in the world for the manufacture of this type of machinery, and this statement is fully borne out by the fact that the company have supplied cable-making machinery for practically every European country, also for Japan and many other places abroad.

The illustrations show a few of the leading types of machines. In all cases particular attention has been given to the rate of output, and the makers claim to have turned out the fastest-running stranding or armouring machines ever produced. A large stranding machine is shown in Fig. 1. This machine runs at a speed of 120r.p.m., and has a capacity of 8 miles of conductor per day of twelve hours. The revolving cage is supported at the leading-in end by the central shaft, and further by pairs of rollers under each of the three discs, the main bearing and the bearings of each of the rollers being special roller bearings of large area. All these bearings are of the swivel type, and their coefficient of friction is so low that the power of the driving motor needed is only one-third of that required for a similar machine with plain bearings.

Whilst the speed of running is a very important consideration in cable-making, it is very desirable that the supply of materials to the machines shall be effected as easily and quickly as possible. It is necessary to adopt an efficient and ready means of replacing the wire bobbins and of making joints, &c. For this purpose electric hoists above the machines are recommended, and the makers construct the bobbin carriages in such a manner that the bobbins of wire may be dropped into the carriage, which supports it temporarily until the spindle is inserted,

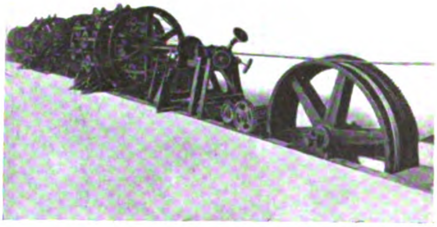


Fig. 1. A Large Wire Stranding Machine

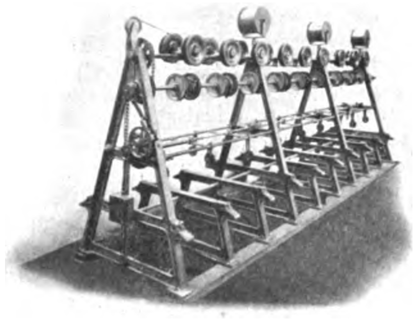


Fig. 2. Standard Paper-lapping Machine.

the act of which automatically lifts the bobbin off its temporary bearing and leaves it free on the spindle, the spindle being automatically locked by a spring catch.

For making the joints in the wires electric welders are employed, and a joint is made in one or two minutes.

Machines of this class, owing to their high speed and the heavy strains to which they are subjected, are comparatively expensive, and there are very few concerns who care to afford the outlay, but in these days of hustle, when it becomes necessary to be able to turn out long lengths of cable in a short time, they must eventually be adopted.

For electric light and power cables the stranding machines, &c., are designed for a maximum speed as far as it is possible, without incurring undue expense, and the makers adopt the before-mentioned principle for quickly loading, &c.

For paper-insulated cables there are several different patterns of paper-lapping machines to suit the requirements of different customers, but the standard machine as shown in Fig. 2 consists of a number of heads, each head carrying three spindles, and each spindle arranged to carry three discs of paper, so that each head is capable of putting on nine coverings of paper at one operation. The machine shown is fitted with twenty-four spools, but Messrs. Johnson & Phillips have made several machines with as many as eight heads, and equal to seventy-two layers of paper, for high-tension cables. Fig. 3 shows an eight-headed horizontal paper-lapping machine.

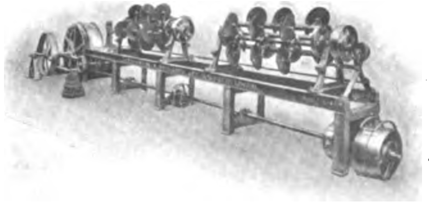


Fig. 3. Horizontal Paper-lapping Machine.

For drying and impregnating the paper insulated cables, are supplied large pans about 7ft. diameter by 3ft. deep. The pans are fitted with steam-heating coils at the bottom and at the sides, these coils being free from joints inside the tank so as to obviate any risk of leakage of moisture into the tank. The tanks have a dished cover arranged to be hermetically sealed, and the process of drying is hastened by connecting the tanks to a vacuum pump which draws off the moisture, passing it through a condenser from which it can be collected and weighed.

For testing the dryness a glass is applied at the exhaust outlet of the pump, and the pumping is continued until there are no traces of vapour.

The tanks are also connected to a tank of compound, and when the cable is thoroughly dried, and while still under vacuum, the valve on the compound pipe is opened and compound passes into the tank with the cable, into which it thoroughly percolates.

The lead cable-covering press consists mainly of a lead chamber at the centre of which dies are fitted, the point or male die being supported by the back end of the chamber, while the matrice or female die is held by the front end of the chamber, leaving a clear channel between for the lead to reach the cable which is drawn through the centre of the dies. The lead in the chamber is compressed from two sides by plungers under hydraulic pressure, and it is uniformly faced out through the female die carrying with it the cable. The cable is then passed over oiled pads or through water to prevent it sticking together on the receiving drum.

This style of lead press will cover a cable of any length, as each successive charge of lead forms a homogeneous mass with the previous charge, and with ordinary care there is no risk of "seams" in the lead covering as there is with some other types of presses.

The armouring of lead-covered cables is

effected either with iron or steel tapes, or with steel wires. The latter entails practically a stranding machine with one or two jute serving discs and compound tanks.

For steel taping a special head is necessary. The head designed by Messrs. Johnson & Phillips is of very heavy construction, arranged to carry two discs of iron or steel tape, and each disc is provided with independent screw adjustments so that one may be set in advance of the other as desired, also screw adjustment to set the angle of the disc exactly. This screw adjustment forms a perfect lock, and it is impossible for the setting to alter itself when once fixed. The head is driven by a patent silent-drive chain, ensuring quietness of running.

The complete machine is illustrated by Fig. 4, and it further comprises several jute-serving discs and compounding tanks, and also a whitewash tank to give a final covering of whitewash to prevent the turns sticking together on the drum.

As there are many thousands of miles of small indiarubber-covered cables always in demand, it is necessary to employ multiple covering machines for this work. Messrs. Johnson & Phillips have given special attention to this line, and they supply machines for covering up to twenty-four wires or conductors simultaneously, with two, three or four coatings of rubber. When working twenty-four wires, the maximum diameter would probably be ⅜in., but the machines will also do a smaller number of larger sizes by using suitably grooved rolls.

The machine used is designated a longitudinal rubber-covering machine, and it consists of two, three, or four heads, according to the number of coverings required. See Fig. 5. Each head consists of a pair of grooved rolls carried in a strong housing; between the heads are arranged supports for the rubber, with guides for the wires and rubber. The wires (twelve, eighteen, or twenty-four, as the case may be) are passed side by side between the rolls (which are suitably grooved to take the wire with a thickness of rubber) with a strip of rubber above and another below, and the rolls being revolved, the wires and rubber are drawn through the rolls, crushing the two rubber strips together between the wires, and thus giving each wire a complete covering. The wires emerge as a wide band, but are easily separated at the crushed portion.

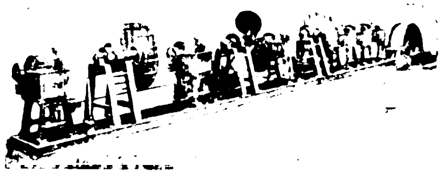


Fig. 4. Armouring Machine.

Each head acts similarly, and the finished wires or conductors are hauled off on to separate drums. In the ordinary way there are several stoppages on this machine for replacing the discs of rubber tape, as they usually contain only small lengths, and there are two discs to each head, so with a four-head machine there would be eight stoppages in running off each disc. The makers have, however, devised and adapted a special arrangement of bracket and guide by which they are enabled to complete lengths of a quarter of a mile without a stop, and consequently trebling the output of the machine. For odd lengths of the larger rubber-covered cables it does not pay to make them in the longitudinal machines, so they are made in horizontal lapping machines, in which this work can be done without the use of expensive and specially grooved rolls.

These rubber-covered wires are usually taped previously to vulcanising, and this operation is performed in vertical taping machines having four heads, each head carrying one bobbin of tape. This is another machine to which the makers have given special attention, and each machine will turn out twenty miles per day of ten hours with one attendant.

The vulcanising of cables is done by subjecting the covered wires to certain temperatures for certain periods of time, according to the quality of the rubber, &c. Steam-heating is used for this purpose, and in order to take full advantage of the cubic contents of the vulcanising pans there has been devised and adopted a system of telescopic drums which nest in one another. By this arrangement about three times the usual quantity can be vulcanised in one batch.

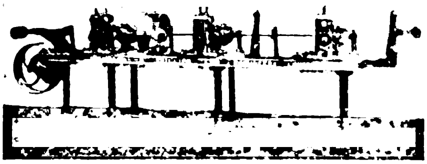


Fig. 5. Rubber Covering Machine.

The taped and braided cables are saturated with thin compound, and then receive outer coverings of thick compounds, which are applied by passing the cable through steam-heated compound tanks. A long drift is allowed so that the compound sets hard and glossy before the cable reaches the drum. The makers supply compounding apparatus and hauling-through gear to suit all sizes and classes of cables. The company has also developed a line of special machines for the production of bitumen cables, in which a rapidly-increasing business is being done.

Before concluding this description of cable-making machinery it should be recorded that the preparation of commercial forms of rubber as sheeting, tape, &c., forms a further speciality of this firm. The preparing, mixing, and washing machines turned out for the working of pure rubber are of particularly massive construction, and have been very extensively adopted.

Cables.

In the cable department of the Charlton Works are manufactured every variety of cable from bare stranded wires suitable for overhead transmission lines. These products include vulcanised indiarubber cables of various grades and sizes; also paper-insulated, lead-covered, and armoured cables, and Paterson's vulcanised bitumen cables. The special features of the last are that the material is perfectly non-hygroscopic and is practically unaffected by oxidising agents or corrosive chemicals; it is not brittle at ordinary low temperatures, nor unduly soft at the highest temperatures met with in practice; it is also very flexible and light, and is suitable for use in positions where the conditions are against the use of rubber cables even of the highest quality.

Another of the cable specialities is the Paterson's patent fire-resisting cable, which is specially suitable for use in situations where the temperature is likely to be high, and also where there is a danger of fire. This cable withstands the action of internal arcs, and in the case of external fire it is no less well protected, for the steel fireproof reinforcement contained in its construction gives great mechanical strength. It is made

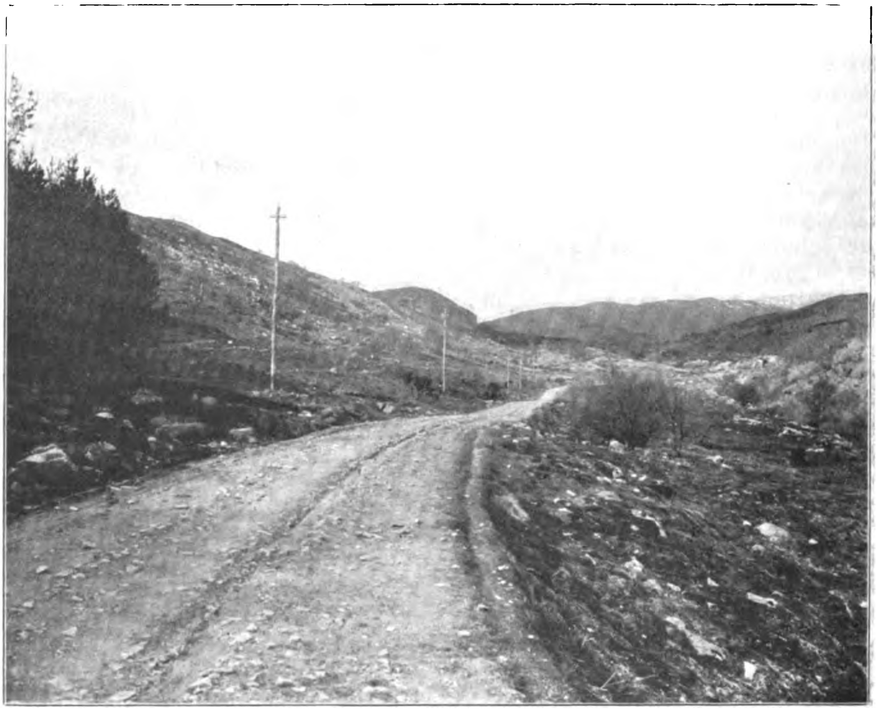


FIG. 6. EXAMPLE OF OVERHEAD POWER TRANSMISSION LINE.

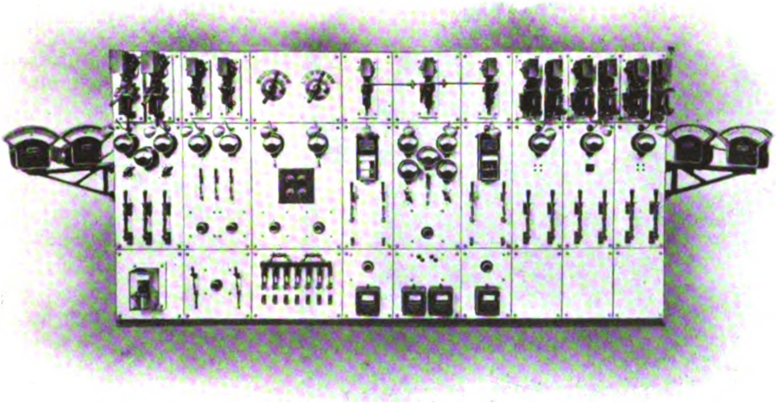


FIG. 7. COMPLETE POWER-HOUSE SWITCHBOARD.

in all sizes, and is eminently suitable for all power and lighting purposes.

It is only in keeping with the progressive policy of this Company that they should also manufacture both bare and insulated aluminium cables and wires. These cables, insulated with Paterson's vulcanised bitumen and being cheaper than those with copper conductors, are likely to meet with great demand. They are also listed with paper and rubber insulations, so that all practical requirements are met. The use of aluminium conductors is not unknown in Canada, an important installation being the 10,000 volt transmission line from Shawinigan Falls to Montreal.

Transmission Lines, Switchgear, & Transformers.

In addition to the supply of every description of insulated conductor, from telephone and gutta-percha covered wires to heavily armoured submarine cables and underground mains, Messrs. Johnson & Phillips also supply large quantities of land line material for our various Colonies; this includes all the necessary insulators, poles, brackets, lightning arresters, wires, tools, batteries, instruments, &c. They have carried out the complete erection of transmission lines in many parts of the world and are prepared to quote for either copper or

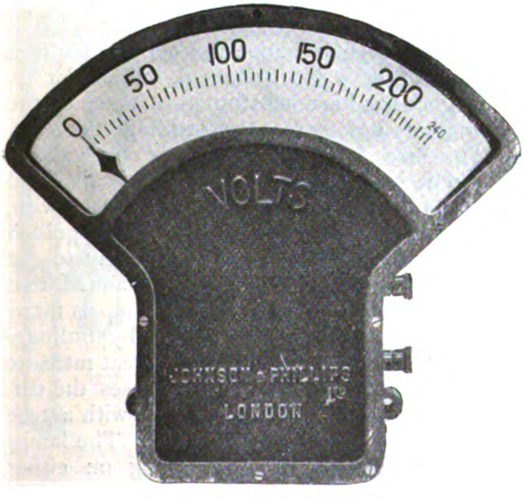


FIG. 8. SECTOR INSTRUMENT.

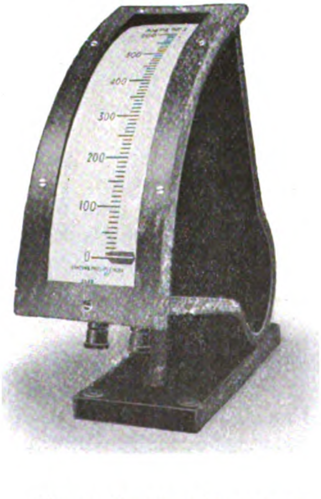


FIG. 9. EDGEWISE INSTRUMENT

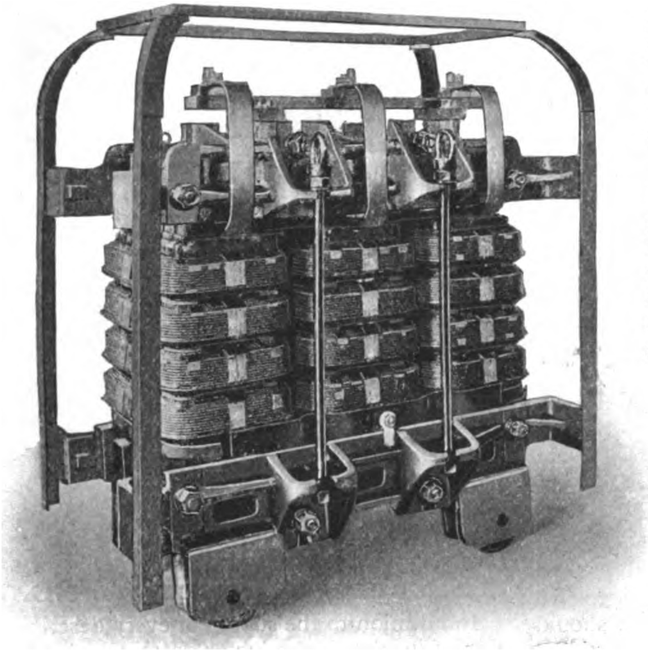


Fig. 10. Interior of Three-phase Transformer.

aluminium aerial cables. The illustration on page 36 shows a transmission line recently erected by this firm.

Other products for electric power supply systems include every variety of disconnecting box, fuse box, house-service box, feeder box, distribution box, and, in fact, joint boxes, frames and covers of many different patterns. In addition, they manufacture a considerable number of feeder and switch pillars which are designed in order that their contents may be as easily accessible as possible.

In the switchboard department is undertaken the manufacture of extra high-tension, high-tension and low-tension switchboards of any size. At the present time there are passing through the works nine very large high and low-tension switchgear equipments for the London County Council tramway sub-stations. Amongst recent work completed in this department it is interesting to note an extra high-tension switchboard and transformers for Nairobi, East Africa.

The work of instrument-making forms a distinct speciality of this all-round electrical manufactory. The instruments made include spring controlled, dead-beat, moving-iron ammeters and voltmeters, also instruments of the hot-wire and permanent magnet-moving coil types. The illustrations Figs. 8 and 9 show respectively the sector-shaped and edgewise permanent magnet moving-coil voltmeters.

For the past sixteen years Messrs. Johnson & Phillips have given great attention to the manufacture of transformers, and have recently adopted new designs which enable them to turn out apparatus of high electrical efficiencies at all loads, whilst the voltage drop on both inductive and non-inductive loads is exceedingly low, and the temperature rise on any part of the transformer is reduced to a minimum. Oil-cooled transformers offer advantages with regard to insulation, overload capacity and the dissipation of heat, and the makers strongly recommend the adoption of this type, although they manufacture air-cooled apparatus also.

Arc Lamps and Projectors.

One of the chief demands of the electrical market in Canada is for flame arc lamps. In this particular branch the types illustrated in Figs. 11 and 12 are deserving of attention. In the former, known as the "Magnet Juno," the carbons converge. It has now been on the market for some considerable time and is really an adaptation of the earlier Juno Lamp, the general features of which have been retained, but an electromagnet has been substituted in place of the original hot wire, for striking the arc. The feed is effected entirely by gravity, and it is noteworthy that shunt-coils and dash-pots have been entirely dispensed with.

The colour of the light is either golden yellow or brilliant white; according to the grade of carbon used. It is claimed that the illumination given by this lamp is many times greater than that given by ordinary arc lamps; this being due in great measure to the special design, which causes the carbons to burn economically and with a true flame of extraordinary brilliancy. The lamps are suitable for series working on either continuous or alternating current circuits,

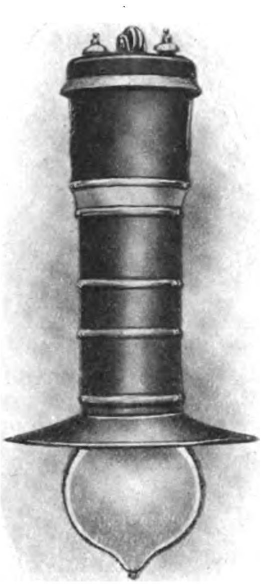


Fig. 11. "Magnet Juno" Flame Arc Lamp.

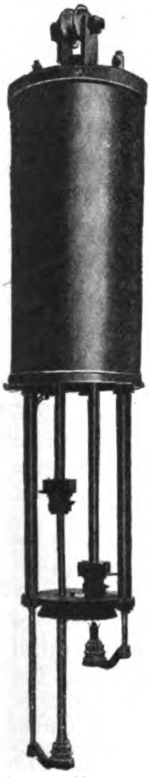


Fig. 12. Vertical Type Double Carbon Flame Arc Lamp.

allowing 50 to 55 volts per lamp. Every lamp is tested at the Johnson & Phillips Works under the conditions of circuit on which it is to run, and is fully guaranteed by the makers against failure.

The double carbon lamp shown in Fig. 12 is also of the flame type, and is conspicuous in that the "flame" principle has been applied to the vertical carbon arrangement. Only recently placed on the market, a large number of these lamps are already in use, and are much appreciated. It is claimed to have a very high efficiency, and gives the typical flame arc light of pale yellow tint. For continuous current working only the positive carbon is impregnated, and it is carried by the lower holder. By this arrangement the largest possible proportion of the mineral salts contained in the positive carbon is utilised in the flame. In alternating-current lamps this arrangement may also be adopted or both carbons may be impregnated.

One very special feature of the lamp is that a very low current (from 3 amperes upwards) may be employed, and four or even five lamps may be connected in series on 200 volt to 220 volt circuits. These low current lamps are consequently very suitable for small shopkeepers, to whom the cost of current for the ordinary 400 watt or 500 watt lamp would prove prohibitive; not to mention that the arrangement of the shop lighting is best served by the use of a number of brilliant small current arc centres. For street lighting, railway station works, and dock illumination the makers recommend 7 amp. to 10 amp. lamps, these being specially suitable for such services owing to the angle at which the maximum light is emitted, ensuring an even distribution over a large area, and to obtain which result it is not necessary to install the lamps at an inconvenient height.

Quite a unique piece of apparatus which

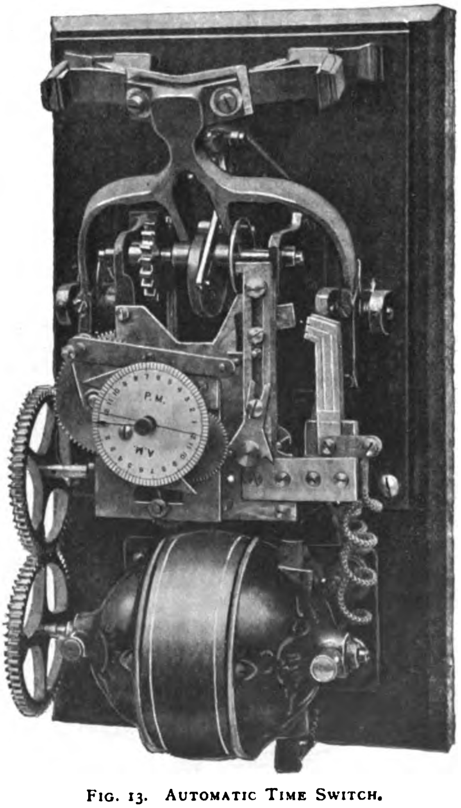


Fig. 13. Automatic Time Switch.

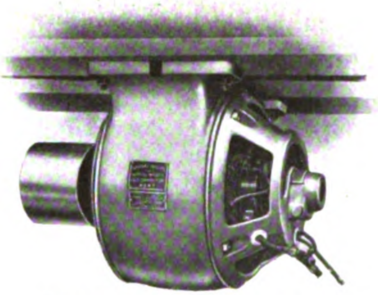


Fig. 14. Direct-current Motor.

Messrs. Johnson & Phillips supply for use with lighting systems is their automatic time switch (Fig. 13), which, whilst it can be used for the automatic opening and closing of any electrical circuit at definite hours or times of the day, is specially serviceable in connection with arc lamp lighting, as by its aid lamps can be automatically switched on or off without the attendance of a man. This is believed by the makers to be the only absolutely automatic time switch on the market, in that it requires no attention whatever after installation, as the clock is automatically wound. It is suitable for use with either alternating or continuous current circuits.

A further arc lamp speciality of this firm which has been adopted in foreign countries is a special form of search-light projector designed for use as locomotive head-light.

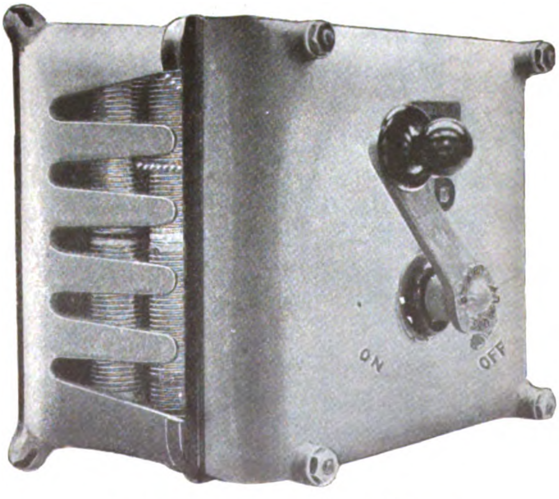


Fig. 15. Enclosed-type Motor Starter.

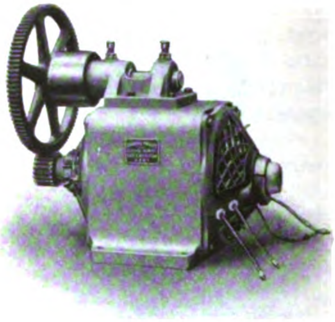


Fig. 16. Back-geared Motor.

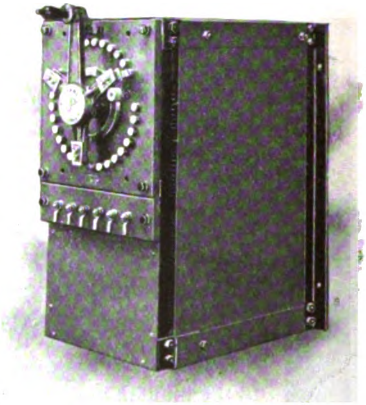


Fig. 17. Three-phase Motor Starter.

Power Plant.

With regard to the Johnson & Phillips dynamo machinery, their standard designs are so well known as to call for no detailed description here. The several illustrations, Figs. 14, 16, 18, 19, and 20, show the standard types, which include both direct-current and polyphase generators and motors.

The machines are throughout of generous electrical and mechanical design; each part is standardised, the principles adopted represent the most modern practice, and high electrical and mechanical efficiency may be relied upon. Every machine is thoroughly tested before being despatched from the works. The machines made include motors which are specially suitable for wood-working machinery and driving machine tools, &c.

It will be seen from the illustrations that the dynamo-electric machines cover a wide range of type and sizes. Generators are supplied either for belt-driving or for direct-coupling to the prime mover. The motors are suitable for all classes of drive and any conditions of work as to situation of machine or nature of load. Fig. 14 shows a standard direct-current machine as arranged for suspension from the ceiling. Fig. 16 illustrates a compact little motor set which is fitted with a self-contained speed-reducing gear consisting of a raw-hide pinion, cut-steel gear wheel and second motion shaft rigidly assembled on the motor itself. There is a similar completeness in the range of designs of motor-starting and controlling apparatus manufactured by this firm: typical examples are illustrated in Figs. 15 and 17.

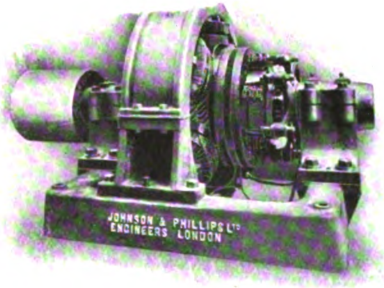


FIG. 18. BELT-DRIVEN DYNAMO.

In concluding this notice of some of the leading specialities of a British firm it should be recorded that they are regularly engaged in an immense amount of Colonial work and find themselves particularly well situated for carrying out work abroad, as they are in the position of being able to manufacture the whole of the electrical part of an installation, including both the cables and machinery; they are therefore not dependent upon sub-contractors, but are able to take full responsibility for any electrical power scheme. And being manufacturers of both alternating and continuous current plant they are unbiased and free to adopt the plant most suitable for the work to be done.

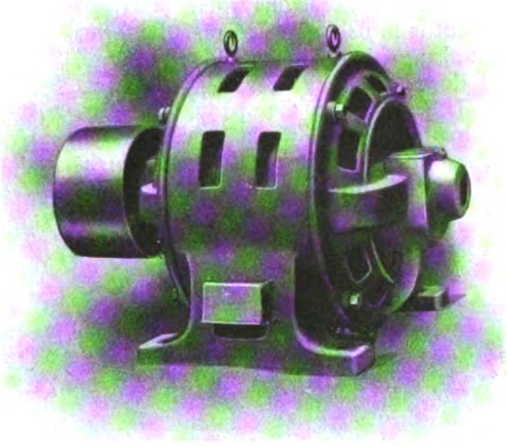


FIG. 19. ALTERNATE-CURRENT MOTOR.

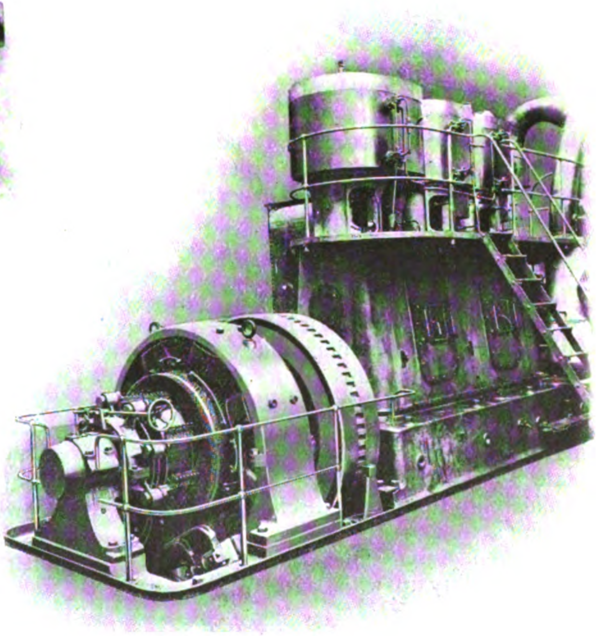
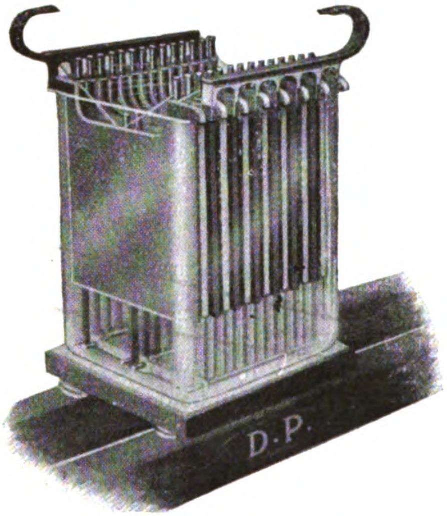


FIG. 20. DIRECT-COUPLED STEAM-DRIVEN GENERATING SET.

Storage Batteries.

THERE are few occasions where electrical plant is in use when storage batteries may not also, with economy and advantage, be laid down.

The D.P. Battery Company have extensive manufacturing works at Bakewell, in Derbyshire, England, on the site of Arkwrights' (of spinning machine fame) first mills. As founders of the industry who have had over thirty years' experience, they have adopted the Planté plate formed by an improved process of electrolytic action with a tough, closely-adherent coating of lead oxide. The use of mechanically applied oxides (pasted plates) has inherent failings which are understood to be overcome by this process. The advantages of this formation of coated oxide plates are found in the greater resistance of the plate to "buckling," giving an applicability to a rapid discharge which a few years back was considered impossible, and a general ability to withstand the hardest usage.

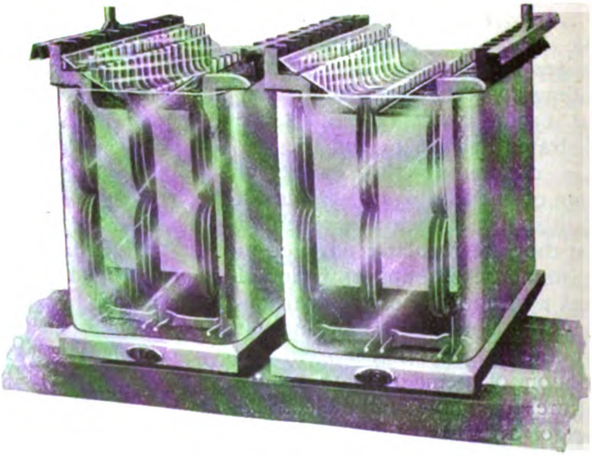


"L" Type of D.P. Battery Cell.

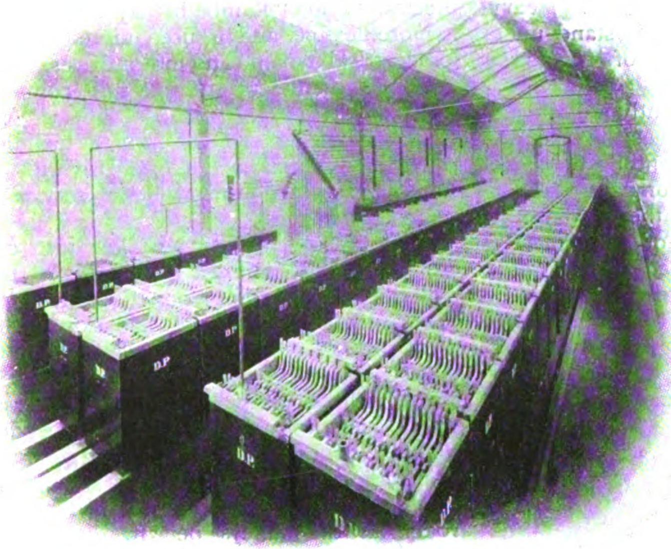
For train lighting and all purposes of vehicular traffic these points are of the utmost importance, as it is not possible for the batteries themselves to have close attention whilst they are in actual operation. It is noteworthy in this connection that the makers undertake maintenance of the battery capacity and the replacement of plates on ordinary terms. A further point claimed by the company is their use of only pure lead, which leads to greater conductivity, reduces to a minimum the internal resistance as well as the liability of the plate to fracture under the stress of charging, and maintains the homogeneity of the elements. The tough skin formation, which, as said, enables the plates to effectively withstand hard usage, renders them particularly suitable for country house lighting and similar work where often as not the plant is placed in the hands of a more or less unskilled attendant. The design of the plate presents an enormous area to the action of the acid, which, with the freedom from buckling, renders the battery specially suitable for power stations where heavy discharges are necessary.

The efficiency and long life of the battery is demonstrated by the fact that plates supplied by the company as far back as 1890 are in use to-day and still giving satisfaction. The makers state that these are not isolated instances, but that cases are constantly coming to their knowledge in the way of renewals.

The Company has for a considerable time past been devoting particular attention to railway and traction requirements, and have succeeded in producing plates which are practically immune to the effects of over-



Two Cells of D.P. "L.H." Central Station Type.



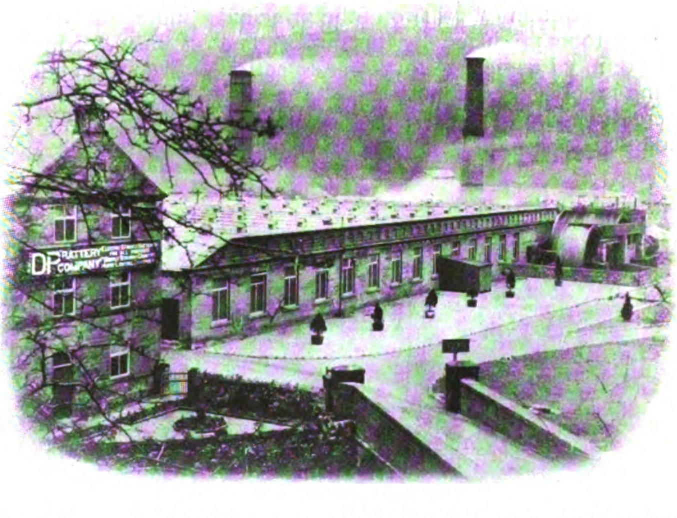
Complete Power Station Battery, "L.S." Type.

charging, the fatal danger of this class of battery.

Of particular interest is the recent completion of a large power installation for the operating of electrical cranes, where the provision of storage batteries has effected a material economy. The intermittent demand for power in such cases is well met with a storage battery plant by which a considerable reduction can be effected in the size of the generating plant, and also in its daily working expense, since an economical load is provided during the hours of running.

There is no purpose or circumstance for which the D.P. Company are not prepared to design a battery; they also lay themselves out for renewals or exchange of any make of plate, and having their own reducing furnaces the Company are prepared to offer liberal allowances for old plates of any type. The output of the works runs to hundreds of thousands of plates yearly of all sizes, and they are consequently in a position to execute the smallest or the largest installations. Reference may be made to contracts undertaken for the British Admiralty and War Office, General Post Office, colonial governments, municipalities, railway and tramway companies, country houses, hospitals, and other public institutions, mills, factories, &c., in all parts of the world.

Whilst recognising that efficiency must be precedent to price the makers are nevertheless in a position to manufacture at the lowest cost consistent with the best workmanship and material. The works standing charges are at a minimum, since use is made of a local water power supply



Frontage View of the D.P. Battery Company's Works, at Bakewell, Derbyshire.

as against steam power, which latter is used only as a supplementary power. Heavy rentals are avoided, as the works stand upon the Company's own freehold of 15½ acres of land.

The works have been recently remodelled and largely extended to meet the requirements of a continuously extending business, and this has enabled the company to compete successfully abroad, as they have in the home trade, for installations of all characters.

The batteries are supplied under a free guarantee for two years against any defect of workmanship or material and the makers are prepared to enter into agreements for the maintenance of their batteries on easy terms in perpetuity or for any desired number of years.

Rope Drives.

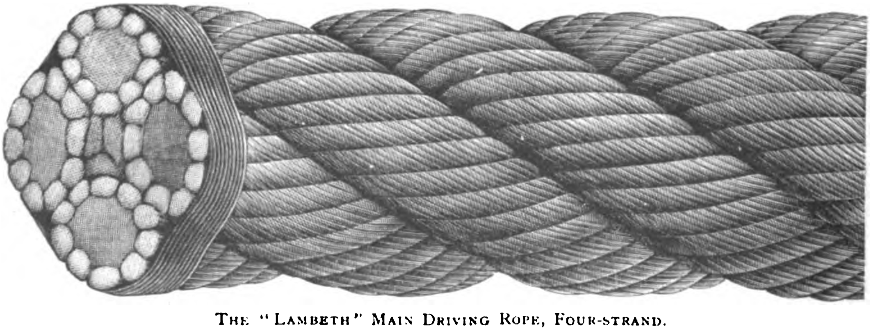
As a manufacturer of cotton ropes for power transmission, Mr. Thomas Hart, of Blackburn, has received orders from many parts of the world. What are probably the largest driving ropes ever made were supplied by him for the Washington power station of the Chicago Street Railway Company; the ropes are 3½in. in diameter. At the present moment he has in hand a large order for a new mill in Canada; in this case the mill is equipped with an electric motor in each room, the drive between motor and shafting and to counter shafts being by rope and grooved pulleys.

The illustrations show two of the principal types of rope produced by this firm. The first, the "Lambeth" four-strand cotton driving rope, is used for steam engine and general high-power, lower-speed drives, since it adapts itself well to pulleys of comparatively large diameters. The second type illustrated, the "Lambeth" lay thread rope, is more flexible, and is used more generally for electrical dynamo and motor drives, where the pulley diameters are, as a rule, comparatively small.

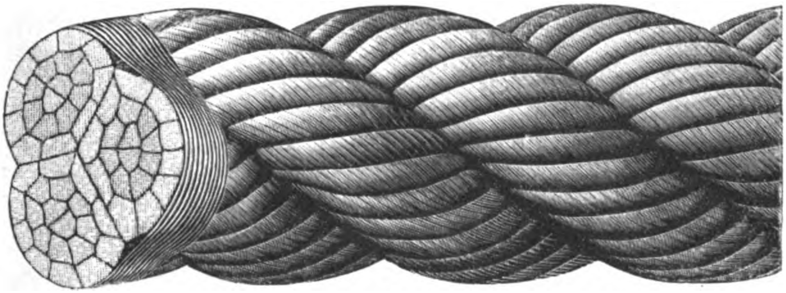
The following extracts from a technical publication entitled "Rope Driving," by Mr. Hart, will doubtless be of service to many power users:—

Many points have to be taken into consideration in designing a rope drive, each of which is so dependent upon the others that few general rules can be laid down; the most suitable diameter of pulleys, the most suitable size of rope, the number of ropes—each of these, whilst being dependent very much upon the others, is also dependent upon the circumstances. Speaking generally, it may be said that the pulleys should not be less than thirty times the diameter of the rope. If the pulleys be 3ft. diameter or less, it is best to use ropes of not more than 1¼in. diameter. If the pulleys be up to 5ft. diameter, then ropes up to 1¾in. diameter are the most suitable; ropes thicker than 2in. diameter are seldom used, as the power absorbed by the bending more than covers any gain resulting from the increased strength of the rope.

With electrical work it is important to use the smallest possible size of pulley that can be adopted to transmit a given power. The greater the speed of the dynamo or motor, and consequently the smaller the pulley diameter, the cheaper can the dynamo or motor be constructed for a given power. Whilst bearing in mind the rule previously given for pulley sizes, as far as the smaller diameters of ropes are concerned (say, from 1in. to 1⅜in.), smaller pulleys than the rule allows can be used with but little detriment



THE "LAMBETH" MAIN DRIVING ROPE, FOUR-STRAND.



THE "LAMBETH" LAY THREAD DRIVING ROPE, THREE-STRAND.

to the ropes; for instance, pulleys 2ft. diameter are often used for ropes 1¼in. diameter with excellent results.

In considering the power capacity of ropes, it is as well to bear in mind that a rope will transmit more power than it is advisable to entrust to it. Under favourable circumstances ropes will transmit the powers named in the subjoined table, but as all ropes reduce a little in diameter during work, it is a good rule to always consider 1¾in. diameter ropes as 1⅝in., and so on in calculating the number of ropes required for any given power; a comfortable working margin is then provided:

TABLE OF HORSE-POWER ROPES WILL TRANSMIT.

Diameter of Rope:	in. 1	in. 1⅛	in. 1¼	in. 1⅜	in. 1½	in. 1⅝	in. 1¾	in. 1⅞	in. 2
Speed in feet per min.									
1000 ...	4	5	7	8	10	12	14	16	18
2000 ...	9	11	14	17	20	24	28	32	36
3000 ...	12	16	19	23	28	33	38	44	50
4000 ...	14	18	23	28	33	39	45	52	59
5000 ...	15	19	24	29	34	40	46	53	60

No advantage is gained as far as the power transmitted is concerned by going above this speed. The strain on the ropes at stopping and starting is also more severe, and owing to the action of centrifugal force, the power the ropes will transmit economically is reduced rather than increased at speeds above 5000ft. per minute.

The shape of groove formed a point of much discussion several years ago, but during the last few years there has come about a consensus of opinion in favour of a groove at an angle of 45deg. Grooves with angles of 30 deg. up to 60deg. have been tried, but below 45deg. there is a tendency for the ropes to wedge in the groove, and much power is absorbed in overcoming this tendency; also the ropes become V-shaped, and are much more quickly worn out. An angle of 60deg. would allow the rope to retain its original shape better, but it could not get sufficient grip in such a groove, and slipping would undoubtedly follow. The most suitable angle of groove is that which offers the greatest frictional adhesion without slipping, and at the same time offers the least resistance to the rope in leaving the groove; this angle seems to be found in 45deg.

One of the causes of rope drives not being quite successful is found in the fact that some rope-makers, in order possibly to make the price for the rope lower, do not use cotton yarn of a quality good enough for the work. Or the rope may not be built on principles which will result in strength, pliability, and a low rate of stretch—the three most essential features in a rope for power transmission. The "Lambeth" ropes, whilst possibly not being the cheapest on the market, are always made from Egyptian cotton yarn, a quality specially spun for the purpose. Each strand of these ropes is covered spirally with ten twisted cords of cotton yarn, which serve as a protecting envelope to the inner strand. Thus both the stress and the friction are accurately provided for, the stress being borne by the inner core of each strand, and the friction by the outside threads.

The splicing of the ropes is a very important matter, as on this much of the success of the installation depends. It is not every man, who may be able to splice ordinary ropes for ordinary purposes, that can splice a driving rope. A "long" splice should be used, and the rope should be no thicker at the splice than at any other part.

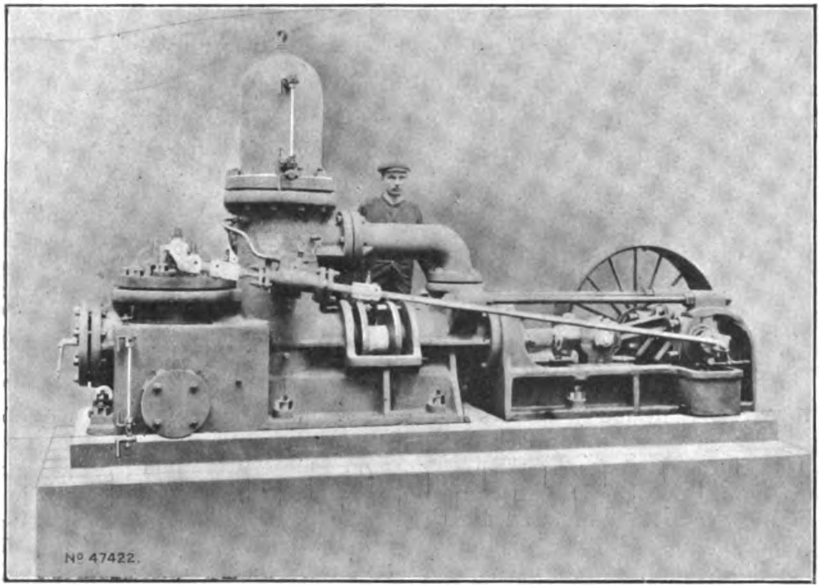


Fig. 1. Differential Ram Type of Oddie-Barclay Pump.

Pumps.

The firm of Andrew Barclay, Sons, & Co., Ltd., Kilmarnock, have had long experience in the manufacture of pumps and pumping plant, and after many trials and experiments have produced the Oddie-Barclay pump. This new pump has much to recommend it, the points made for in its design being to reduce first cost, cost in running, and the space occupied.

As will be seen from the illustrations, the pump is of neat design, the parts are not cumbersome, and it takes up small space in comparison with other pumps.

The pump is of the ram type, its smaller

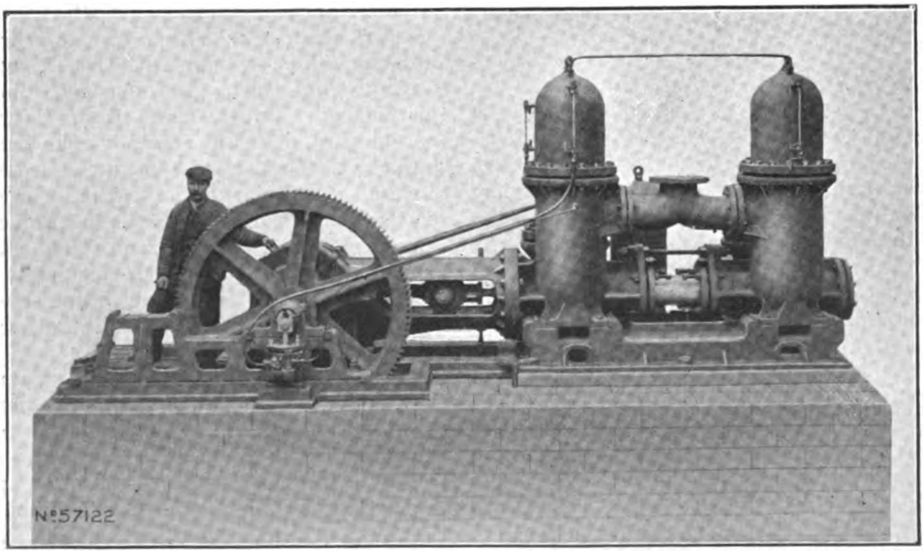


Fig. 2. Double Ram Oddie-Barclay Pump.

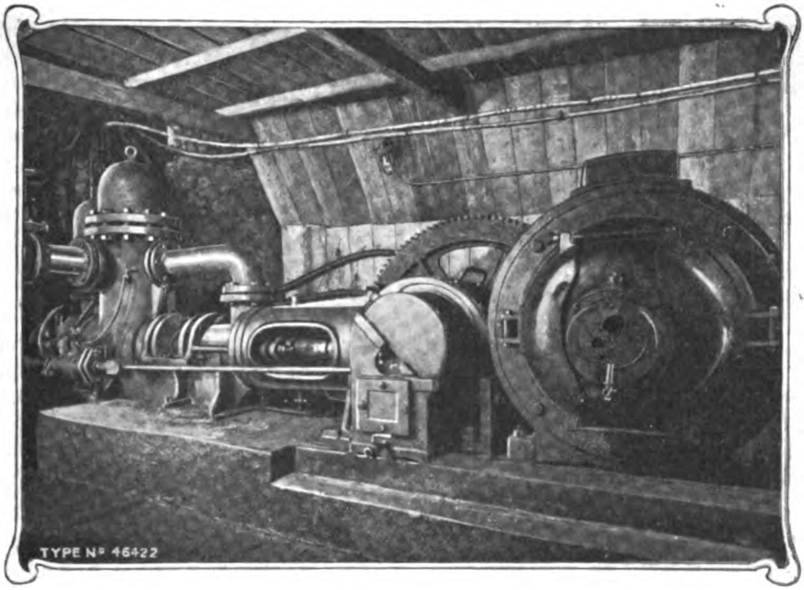


Fig. 3. Electric Pump in the Mine.

sizes having differential rams, it delivers a steady and constant flow of water, and, in fact, with one ram it does the work of an ordinary three-throw pump. Efficient lubrication is accomplished by means of a small force pump, which ensures a plentiful supply of oil over all the bearings and working parts. Probably the reason why this pump can be run at such a high speed is due to the suction valve being mechanically controlled; it is opened and closed by a rod, worked by an eccentric on the crank-shaft.

When the pump is required to work at a high head, an air charger is fitted as seen at the end of the pump-shaft in Fig. 2. The pump has very few working parts, and they are all on the outside, and easily accessible. Efficient priming arrangements, suction and delivery air vessels with gauges are fitted.

Users of electrical plant will be interested to notice that it can be conveniently coupled for an electric drive. It will be seen that the pump shown in Fig. 2 is fitted with an extended bed-plate for the electric driving motor. The pump can be adapted for belt, rope, or other convenient drive, and the absence of double gearing, the mechanical control of the suction valve, and the forced lubrication enable the pump to be run at high speeds and against high heads quite easily. The pumps are constructed for all capacities and for heads up to 1500ft. In actual trials pump efficiencies of over 86 per cent. have been obtained. Large numbers of these pumps are at work and are giving every satisfaction.

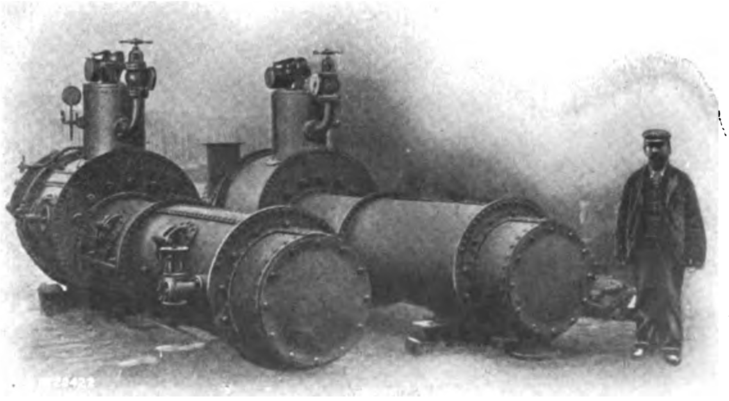


Fig. 4. The Wilson Patent Counterflow Exhaust-Gas Boiler.

Drum-Pattern Power Fan.

The Barclay drum-pattern fan, also made by this firm, is illustrated below. It will be seen that it is substantial and well designed, being firmly built up of steel plates and riveted like boiler work. The inlet is clear of all obstructions and gives a free flow of air through the interior of the fan. A powerful effect combined with a large delivery and high-water gauge when necessary is thus obtained. The fans are excellently adapted for electric driving by motor either direct or by belt or ropes.

Steam Raising from Gas-Engine Exhaust.

In these days of the development of the high-power gas-engine the Wilson patent counterflow exhaust gas boiler merits particular attention of power engineers. Where electrical power is generated by gas-engines, or where gas-engines are used as main power generators, considerable heat economies may be effected by the use of this exhaust-heated boiler, and a large saving of fuel results wherever steam is required. In one works where this plant is used steam is generated from gas-engine exhaust gases, equal to a saving of 70 tons of coal per week. The evaporation of water has been found by tank measurement over a month to be about 4lb. of water per kw.-hour, or, say, about 2½lb. per brake horse-power per hour. It is claimed that by the special patented features of this boiler, which is illustrated in Fig. 4, such a result is alone attainable.

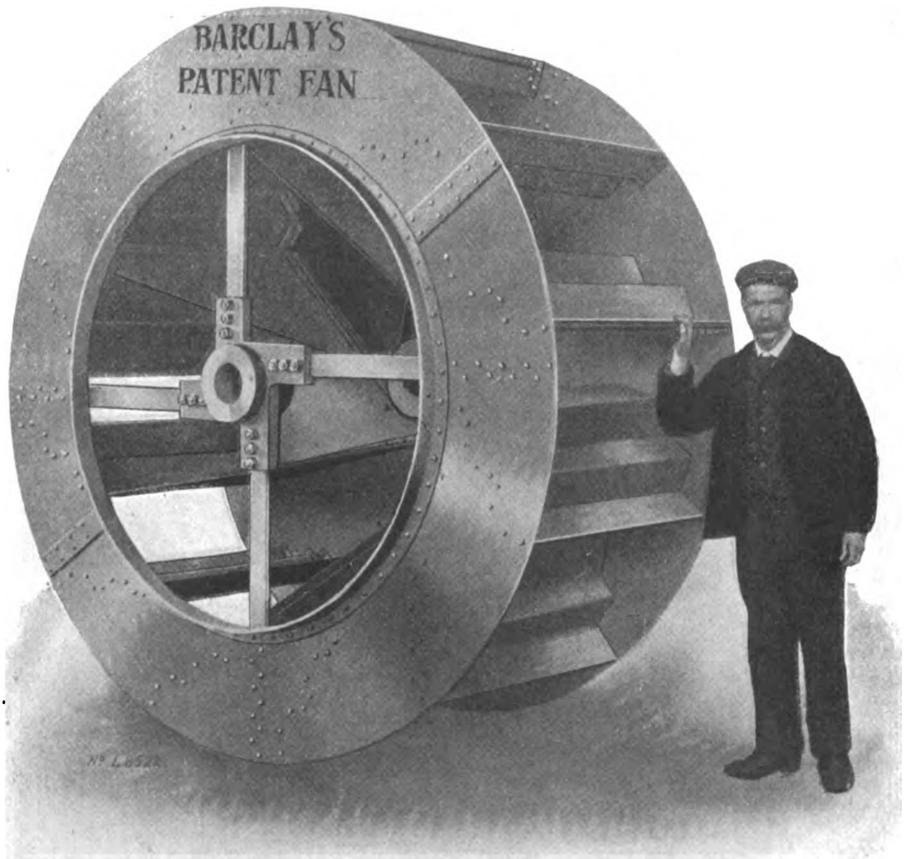


FIG. 5. THE BARCLAY DRUM-PATTERN FAN.

Efficient Refuse Destruction.

QUITE an important branch of modern engineering is that dealing with the disposal of town's refuse, as circumstances, during the past decade more especially, have combined to push the problem to the front and demand a solution.

On the North American continent progress has been slow in this direction compared with that in Great Britain, but one or two notable exceptions must be made to this general statement. One of these exceptions is the municipality of Westmount, Quebec, where for the past eighteen months a modern refuse destructor and power plant has been at work. This plant was installed by the well-known firm of Meldrum Bros., Ltd., Temperley, near Manchester. The adoption of their system was recommended by the town engineer of Westmount, Mr. Fellowes, who was firmly convinced by his observation and experience during a tour in England as to the efficiency and practical success of this system.

The destructor was erected by the makers' engineer from England in the early part of 1906. It comprises three grates or cells on the "Meldrum" top-feed system, the grates being continuous, forming one long cell or furnace chamber. The ash-pit is divided into three portions, each provided with independent steam-jet forced draught, and each section of grate can thus be shut down for clinkering and re-charging with refuse whilst the other two are in a white-hot incandescent state. This is one of the leading features of the system and has contributed largely to its universal success. A Babcock & Wilcox boiler of 2197 square feet heating surface is fired by the destructor gases, and the air for combustion is heated by the waste gases in a "Meldrum" special regenerator.

The success of the plant will be best evidenced by the actual results of the test carried out on May 3rd, 1906, by the consulting engineers to the municipality, Messrs. Ross & Holgate, of Montreal. The test extended over eight hours thirty-two minutes. The weight of refuse burned was 37,550lb., being 4402lb. per hour, and 58.7lb. per square foot of grate per hour; water evaporated 5970lb. per hour, and per lb. of refuse 1.36lb., from and at 212deg. F. The average temperature in the combustion chamber was over 1994deg. F, and the lowest was 1742deg. F.

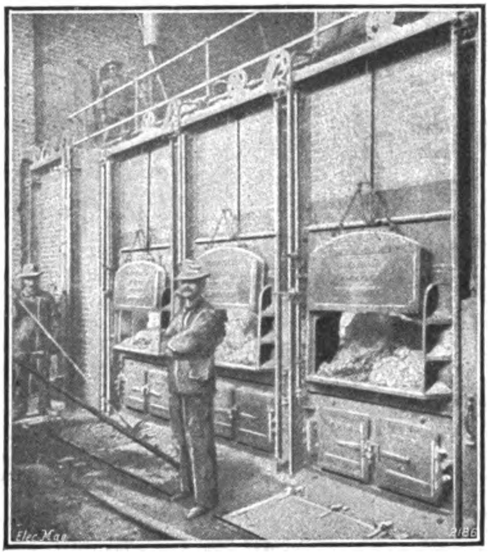


FIG. 1. THE DESTRUCTOR PLANT AT WESTMOUNT, QUEBEC, CANADA.

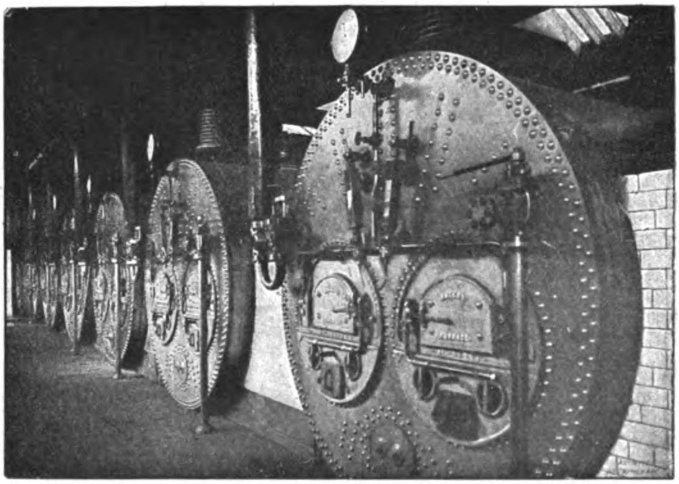


FIG. 2. "MELDRUM" FURNACES ON RANGE OF LANCASHIRE BOILERS.

The illustration Fig. 1 shows the front of the Westmount destructor, *i.e.*, the clinkering floor.

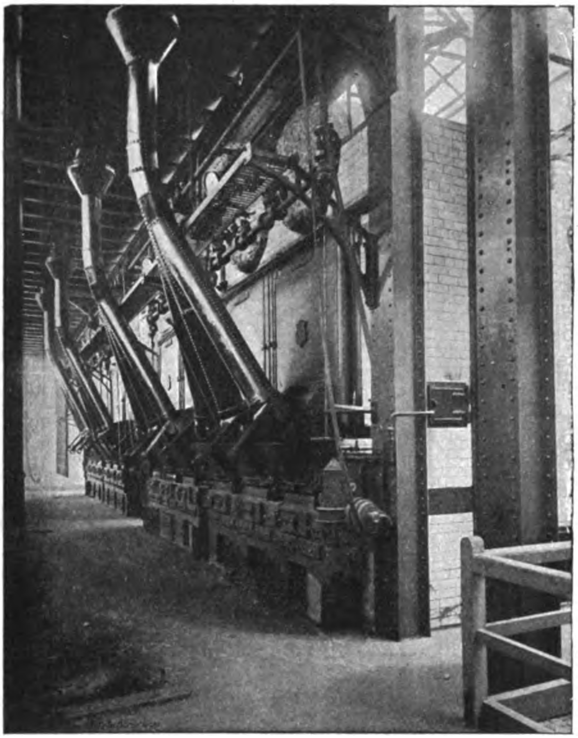


FIG. 3. "MELDRUM" STOKERS ON WATER-TUBE BOILERS AT BRISTOL ELECTRICITY STATION.

This destructor has continued to work in the most efficient manner up to the present time, and its success is conclusive evidence that the method of refuse disposal which has come so largely into vogue in the Home Country is equally suitable for use on the American continent.

Destructors of similar design to this (*i.e.*, for top feeding) have been erected by Messrs. Meldrum in Johannesburg, Christchurch (N.Z.), Toowoomba (Queensland), and other cities, whilst they are now just completing three plants in the city of Paris. The total capacity of these last is 700 tons of refuse per day, and this is the most important destructor contract ever placed.

Others are being erected in St. Gilles (Brussels) and Pretoria. Besides the top-feed type, the firm also make a speciality of front-feed destructors. One of these is now being erected at Seattle, Wash., U.S.A., on the recommendation of the city engineer, Mr. R. H. Thomson, who visited Europe to examine the various makes and then reported strongly in favour of the "Meldrum" system. Another large front-feed plant is just being completed at Prahran, Australia.

Back-feed destructors are also made and are equally successful, so that the particular method of feeding best suited to any class of refuse and local conditions can be provided by these makers.

One of the most successful installations in existence is the front-feed "Meldrum" plant at Preston, England, where about 75 tons of refuse per day is burned, which provides all the power for the municipal electric tramways. The production of current during twelve months ending March 31st, 1907, was no less than 1,461,307 units from refuse alone.

Furnaces for Low-grade Fuels.

The efficient working of steam generating plant, so as to secure the maximum economy with a reasonable degree of freedom from smoke, is receiving marked attention in all commercial communities at the present time. The advantages of "Meldrum" furnaces have been widely recognised in this direction, 14,000 having been fitted in all parts of the world. For increasing the steaming power of the boiler, burning cheap low-grade fuels, such as coke dust, fine small coal, refuse fuel at collieries, tan refuse, and the like, this system is highly successful, and saves its cost in a very short time, whilst it acts quite effectively as a smoke preventer. The British-American Dyeing Company, of Montreal, have the furnaces in use, and the following is a copy of their report to the makers after installing and testing the first set:—

Enclosed please find draft for furnace attached to boiler. I am pleased to say we like it very much. It has been working over four months, and we believe it verifies your claims—it certainly effects a marked economy in fuel, especially in being able to burn a much lower grade. As a smoke consumer, if properly used, it is the best we know of, and it should satisfy the sanitary board of any city. The grate bars are as straight and smooth as when first put in—the clinkers never stick to the bars, and are very easily removed. We are so well satisfied with it that we have given your agent an order for another.

The illustration Fig. 2 shows a range of double-flued Lancashire boilers at a large cotton mill fitted with these furnaces. They are, however, equally applicable to every other design of boiler.

At collieries and gasworks their advantages are especially manifest, as in many cases fuel which has practically no saleable value can be burned, thus leaving all the good coke and coal for market.

Mechanical Stokers.

Mechanical stokers form another leading speciality of Meldrum Bros., Ltd., and, in combination with their system of forced draught, enable the highest possible evaporative power, fuel efficiency, and smokelessness to be secured, though, when desired, the stokers are arranged to work with induced fan draught or ordinary chimney draught.

Fig. 3 shows a battery of four large water-tube boilers fitted with these stokers at the Bristol Corporation Electricity Works. Successive additions to this station have been made until now there are sixteen boilers installed, all being equipped with "Meldrum" stokers. The last instalment comprised four Babcock & Wilcox marine-type boilers, each 19ft. 6in. wide between the walls, the evaporative power being 140,000lb. per hour from the four boilers.

Electrical Tools.

The Phœnix Dynamo Mfg. Company, Ltd., of Bradford, have been experiencing a large enquiry of late for their machines for abroad, particularly for their variable-speed direct-current motors, by which a speed regulation of from 6 to 1, or even as high as 10 to 1, by shunt regulation can be obtained. It is well known that the Phœnix Dynamo Company claim to have been the first firm to introduce the idea of the shortened auxiliary poles, and were the first to bring out a standard line of machines fitted with auxiliary poles. As showing the success met with in this branch, they have supplied nearly 30,000h.p. of such machines during the past three years or so. The illustration, Fig. 1, depicts one of the P.D.M. standard protected type motors, geared to a vertical three-throw ram pump, of which they have recently turned out several sets. These sets are made for various duties and lifts, and such plants will probably be found of much interest to Canadian buyers.

It should be noted that the Phœnix Company have recently placed upon the market a new series of alternating-current motors for two and three phase circuits, which in efficiency, power factor, and cool running, together with moderate prices, compare favourably with those of other makers.

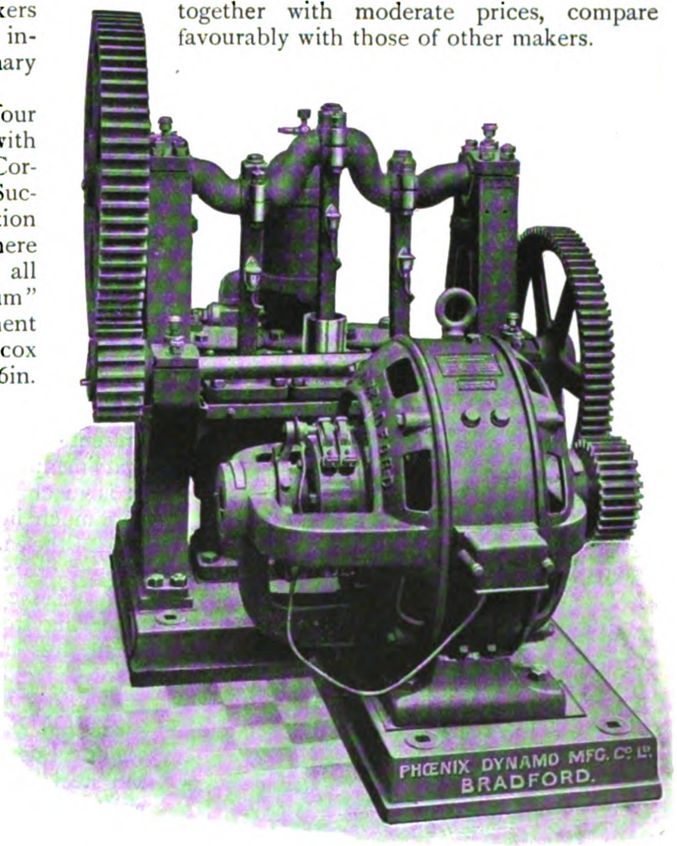


Fig. 1. P.D.M. Motor Driving Three-throw Pump.

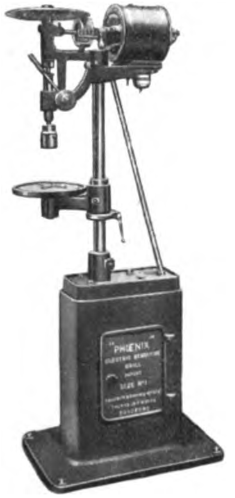


FIG. 2. ELECTRIC DRILLING MACHINE.

A distinct speciality has been developed of late in the form of a standard line of electrically-driven tools. One of these machines is illustrated in Fig. 2.

A further speciality of this department is a combined tool-grinding and disc-grinding machine, as shown in Fig. 3. This machine, as will be seen, is complete with a fully enclosed dust-proof motor, carrying at one end of its shaft a 12in. to 14in. steel disc covered with emery cloth, and having a swivelling table on which the work is held while grinding. This table is provided with angular movements for grinding vertical taper work, and there is also a taper slide on the table for grinding keys and similar small articles into a definite horizontal taper. The other end of the motor spindle is fitted with a 10in. by 1in. emery wheel with tool holders and a guard cover. The machine is sent out complete with a motor-starting switch, as illustrated, which is fitted with a no-load release and also a convenient terminal block for connecting up to the mains. The face of the machine is provided on the one side with a cupboard for holding spares, and on the other side, not shown in the illustration, is arranged a press for putting the steel discs under pressure while the emery paper discs are glued thereon.

Other specialities that the Phœnix Company make include portable hand-grinding machines, also internal grinders for grinding work whilst held in the lathe or other machine, and capable of grinding inside holes from 2½in. diameter upwards.

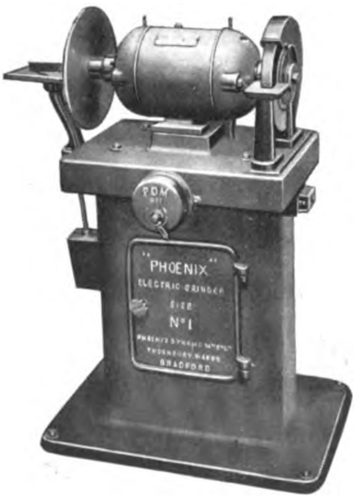


FIG. 3. ELECTRIC TOOL-GRINDER AND DISC-GRINDER MACHINE.

◆

Dynamo-electric Machines.

In these days, when electric lighting and electrical-power transmission are being brought more and more into requisition, and when the possibilities of electrical driving of all classes of machinery are being realised to a greater extent than ever before, a short account of some of the present-day machines made by T. W. Broadbent, Ltd., at the Victoria Electrical Works, Huddersfield, will probably be of interest. A few facts relating to their design and construction should prove of value to both the user of electrical machines and the student. To describe and discuss some modern electrical machines which, it may be said, are distinctively and typically British is the purport of this article.

One has only to look back a few years to realise the great strides that have been made in the designing and manufacture of electrical machines. The dynamo of the present day is a very different article from that manufactured, say, twenty years ago. It is mechanically stronger, more compact, and much lighter in weight than its prototype of the early days. In point of efficiency, also, it represents a very marked advance, the efficiency of good modern dynamos averaging from about 75 per cent. in very small sizes up to as high as 93 per cent. in medium and large size machines—all of which goes to show that the experience of past years has been made good use of by electrical designers, who have learned to put the steel, iron, and copper just where it is wanted, and nowhere else. In continuous-current machines, especially, is this reduction of weight noticeable. Indeed, for a given output at a given temperature rise, the

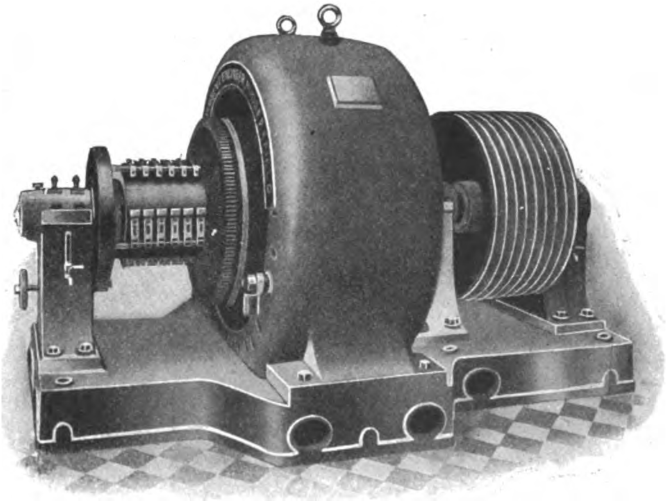


Fig. 1. The Broadbent D-type Dynamo.

weight of a good modern dynamo or continuous-current motor is little more than half of that of, say, an old-fashioned Gramme dynamo. As regards alternating-current machines, a corresponding weight economy has been effected in the case of generators; though in the case of single-phase and polyphase motors the improvement has been mainly in point of efficiency.

The D type dynamo illustrated in Fig. 1 is a good example of an up-to-date electric generator. In this machine special attention has been given to the question of commutation. By judicious proportioning of the parts very satisfactory results have been obtained. These results, it may be noted, have been attained without resorting to the use of commutating poles, or any other special commutating device or winding. Indeed, this firm deprecates the use of such poles except in the case of high-speed turbo-generators, which, owing to the high rate of reversal in the coils during commutation, have an abnormally high reactance voltage per coil, and therefore require a specially strong reversing field.

A brief statement of the points that have come in for attention in the D type dynamo in order to obtain sparkless commutation may perhaps be of some interest. In the first place the armature winding is divided up into a large number of sections, and there are a large number of slots in the core to receive these sections, so that in most of the sizes there are not more than four half coils per slot, which is a not unimportant point. The shape of the armature teeth influences the commutation to some extent; and the teeth are therefore made of the form giving the smallest possible self-induction to the armature coils. The pole tips have been designed with a view to minimising armature reaction as much as possible; and they are built up of thin soft iron stampings, effectively insulated from one another at the tips. As is well known, a strong, *stiff* magnetic field is one of the essentials for securing sparkless commutation; in the D type machine this point has certainly not been lost sight of. The magnet throughout is of massive design, and is heavily wound with well-insulated former-wound coils. The field magnet is of the steel-clad type, with inwardly projecting cores, which are cast in one piece with the yoke. The yoke in the larger sizes is divided horizontally to allow easy access to the armature. The brush gear, which is often the least considered part of a design, is in this machine the outcome of many years' experience and careful experimenting. It was found that the box type of brush-holder, in which the carbon slides in a fixed box, gave more satisfactory results in practice than the hinge type of brush-holder, and it has therefore been adopted as the standard type. It is an essential point in the design of a brush-holder that the pressure, which is applied to the carbon brush by means of a spring, should not diminish appreciably as the carbon wears away. By an ingenious arrangement of the spring this difficulty has been entirely overcome, and a small self-locking wing nut forms an easy and convenient means of adjustment. Different grades of carbon are used on the different machines according to the voltage and the nature of the work for which the machine is required.

In a continuous-current motor the conditions for satisfactory working are very much the same as in a dynamo. The electrical points enumerated above have all to

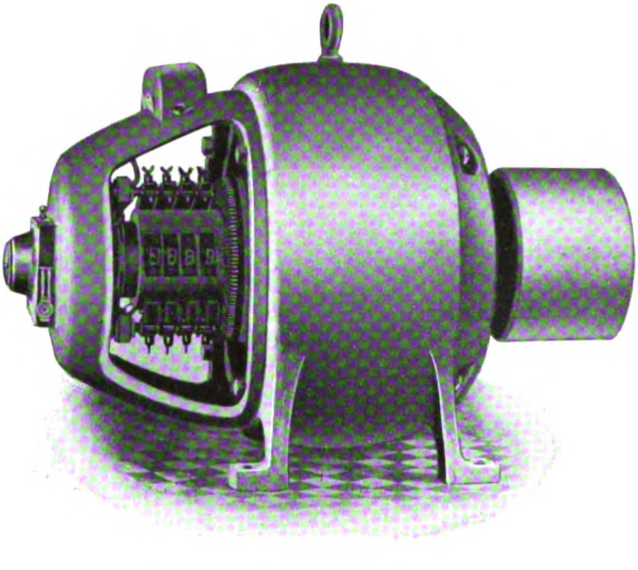


FIG. 2. THE BROADBENT M-TYPE MOTOR.

be considered; and in addition to these there are also several mechanical features that in a motor call for special notice. It is essential, in order to secure perfect rigidity, that the feet or fixing lugs of a motor should be spaced out as widely as possible. Also it is of great importance that the brush gear, commutator, and all working parts of a motor should be easily accessible, which is a point that is sometimes overlooked. The bearings should be of ample surface to avoid heating, and should be provided with an efficient system of oil grooves and automatic lubrication.

The foregoing points have all been satisfactorily provided for in the M type motor (Fig. 2), a new design of motor only recently placed on the market. This type of motor is suitable for almost every class of work where a continuous-current supply is available; and it is made both protected and enclosed, in sizes ranging from 1½b.h.p. up to 150b.h.p. The M type motors are already being employed very largely for the driving of textile machinery, and also for the more severe service required for hoist and crane-work.

A demand has arisen of late years for small motors of a cheaper form of construction. There are many power users in a small way who are well convinced of the advantages of electrical driving, but who do not care to incur anything but a very moderate outlay. To meet this demand, a line of specially cheap motors, known as the C type (Fig. 3), has been designed—primarily with a view to producing a cheap motor for small powers.

The N type induction motor made by T. W. Broadbent, Ltd., is of very substantial mechanical design. It can be wound to suit either single-phase or polyphase supply circuits, but it is listed for the smaller sizes only. Former winding is used throughout, and the coils are heavily insulated.

A motor of particular interest at the present time is the R type single-phase motor illustrated in Fig. 4. This is made in the medium and larger sizes only. It is of the commutator type, and is especially adapted to work requiring a good starting torque and a heavy overload capacity. It is a combination—with certain modifications—of the induction and repulsion types of motor. On the shaft there are mounted two rotors—one with an independent induction winding, and the other (which is provided with a commutator) with a winding of the repulsion class. The speed is approximately constant, the characteristic being similar to that for a compound-wound continuous-current motor. As there is a large number of single-phase generating stations in operation, this motor should have a wide field of application.

In addition to their other lines, Messrs.

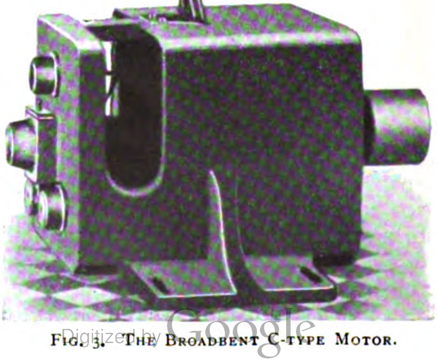


FIG. 3. THE BROADBENT C-TYPE MOTOR.

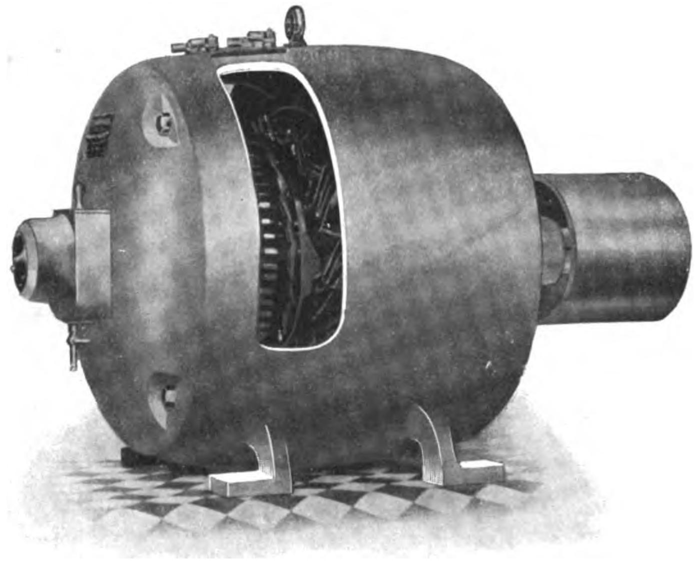


Fig. 4. The Broadbent R-type Motor.

Broadbent are now manufacturing two and three phase motors, and are about to issue a new leaflet descriptive of these motors, which they style the T type motors. In mechanical design they look like the R type motor, shown in Fig. 4. In these motors special attention has been given to the question of ventilation. The rotors are wound, and are provided with the usual slip-rings and brushes.

Of the smaller lines of electrical accessories made by this company, attention need be called only to the H type motor starters (Fig. 5). These form a speciality made only by the above firm; they comprise in one piece of apparatus a double-pole switch, fuses, motor starter and no-voltage and overload release. In fact, the H type motor starter is in competition with the motor-starting panel; and as it is entirely enclosed, and costs much less than the ordinary motor panel, it should have a ready sale.

All the machines made by Messrs. Broadbent are of distinctively new design, embodying all the best features of British and foreign practice. Concerning the firm itself, it may be mentioned that the managing director of the company, Mr. T. W. Broadbent, was the originator of the firm some sixteen years ago, and the designs have been prepared by Mr. Fred W. Davies, who is a director of the company.

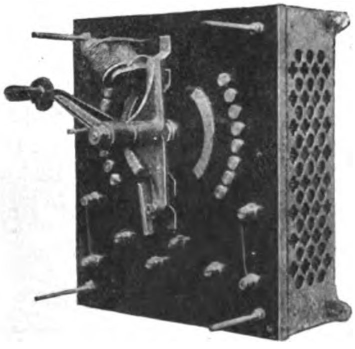


Fig. 5. The Broadbent H-type Motor Starter, with Cover Removed.

Fig. 6. H-type Starter Complete.

Air Compressors.

The use of compressed air has become so much more general of late that the following brief particulars of air-compressing machinery will be read with interest by practical engineers. Besides the most common distribution of air for the working of pneumatic tools and appliances, it has lately been quite extensively used for the raising of liquids, whether it be water from deep wells or oil from oil wells. In mining work also, as our readers know, it is considerably in demand for the operation of small locomotives, rock drills, coal cutters, and similar machines, the air in some cases

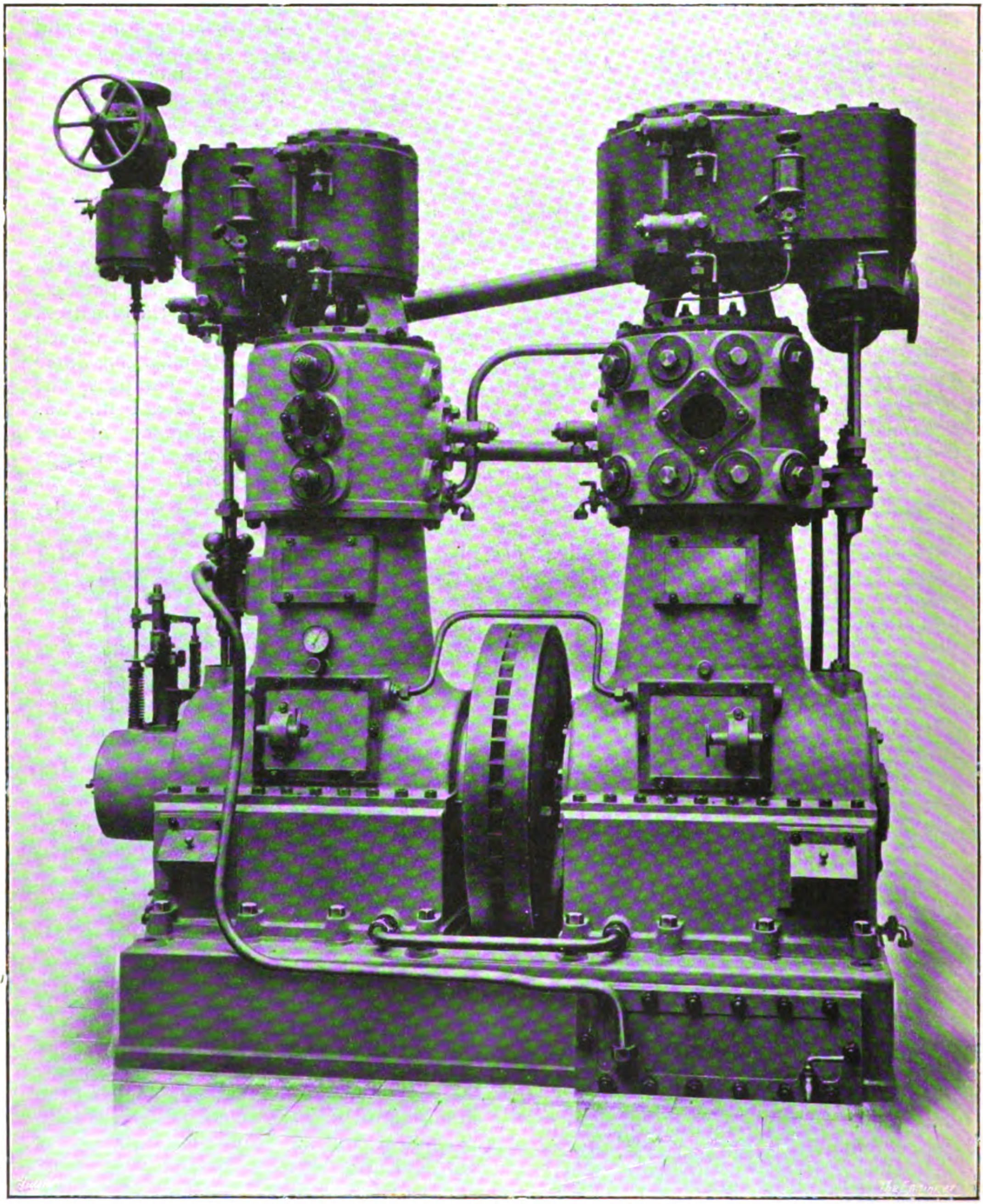


FIG. I. DOUBLE-ACTING, STEAM-DRIVEN AIR COMPRESSOR.

being conveyed in piping from a central point in the pit and in other cases being compressed close up to its work by small machines built specially light and compact for the purpose, and driven usually by electric motors.

The class of air compressor manufactured by Messrs. Peter Brotherhood, Ltd, London and Peterborough, for low and moderate pressures as referred to above is made in two types, namely, with single-acting cylinders from 10 to 300 cubic feet of free air per minute, and with double-acting cylinders for capacities from 300 to about 3000 cubic feet. In both cases these machines are of the vertical and enclosed type, the smaller sizes being fitted with automatic splash lubrication, and the larger double-acting sizes with forced lubrication on a similar principle to that in the Brotherhood and other high-speed engines.

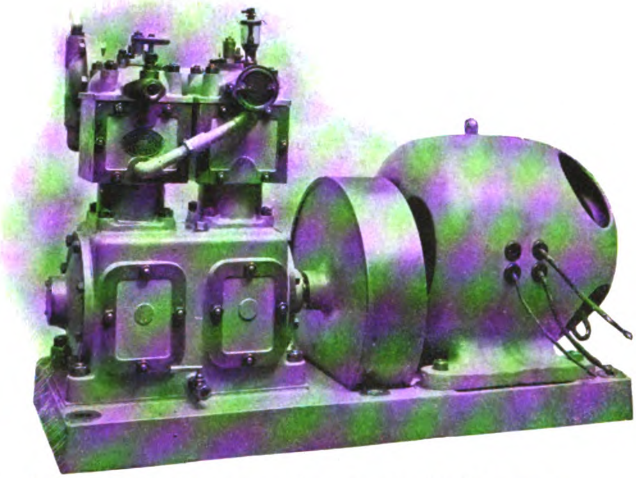


FIG. 2. ELECTRICALLY-DRIVEN, SINGLE-ACTING AIR COMPRESSOR.

Both these types of compressor are suitable for pressures from 5lb. to 500lb. per square inch, and are arranged to be driven either by belt, electric or petrol motor, or direct by steam cylinders fitted tandem fashion over the air cylinders. For all low air pressures up to 70 or 80lb. per square inch, single-stage working is usual, and for higher pressures compression is effected in two or more stages, according to requirements. The machine illustrated in Fig. 1 indicates one of the double-acting forced-lubrication type, driven direct by tandem steam cylinders, this particular machine having an output of approximately 800 cubic feet per minute to 50lb. pressure. Machines of this description are used very extensively in the naval service for air requirements on board ship, such as cleaning boiler tubes and operating small tools, and so forth; also, of course, for use in engineering shops, foundries, mining centres, and similar industrial places. The machine shown in Fig. 2 is of the single-acting smaller type mentioned above, and is shown driven by electric motor through gearing, the plant being mounted on one common base. This illustrates a machine of about 150 cubic feet to 80lb. pressure, and is typical of the design used where moderate outputs of air are required in isolated places, whether for mining, air-lift work, or other commercial purposes.

In concluding this short description, it is interesting to mention that, for higher pressures still, Messrs. Brotherhood have for a great number of years specialised in machines for use in connection with the firing and operation of torpedoes, the air pressure required in this connection varying from 1500lb. to 3000lb. per square inch, according to conditions existing.

Extended facilities at their new works at Peterborough are enabling the firm to take in hand a larger export business, and at the present time compressors under construction are destined for clients in Canada, in connection with mining, air-lift, and general industrial uses.

Coal-cutters, Drills, and Conveyors.

THE coal-getting industry of Canada has already assumed great proportions, and there is ever-increasing activity in this direction. It may be taken that the tendency in Canadian collieries is all towards the full use of modern mining plant. In

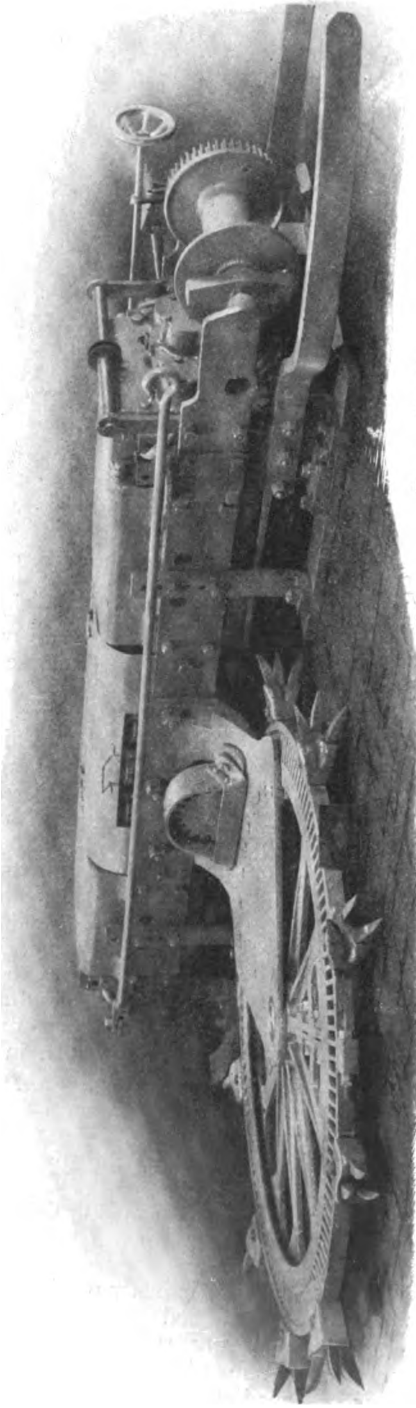


FIG. 1. THE TWO-MOTOR, DIAMOND, DISC-TYPE, ELECTRIC COAL CUTTER.

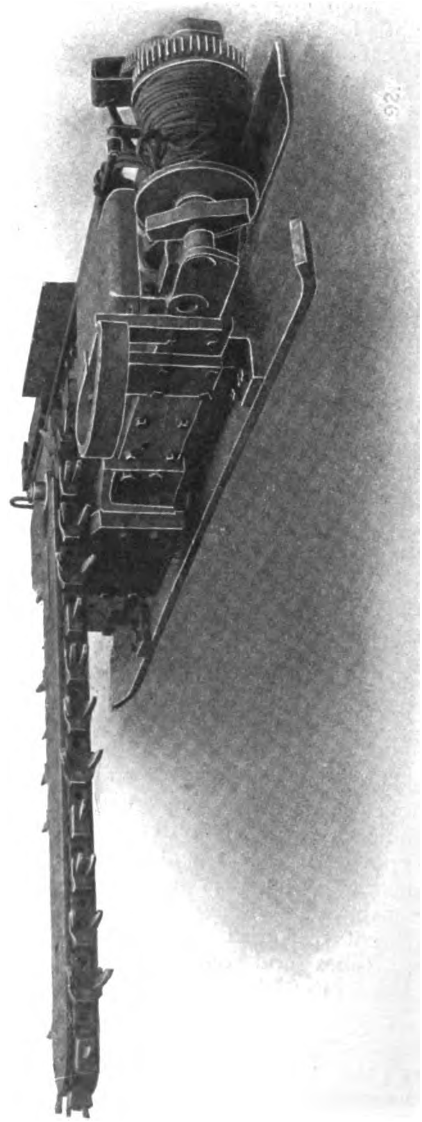


FIG. 2. THE DIAMOND, OVER-CUT, CHAIN-TYPE, ELECTRIC COAL CUTTER.

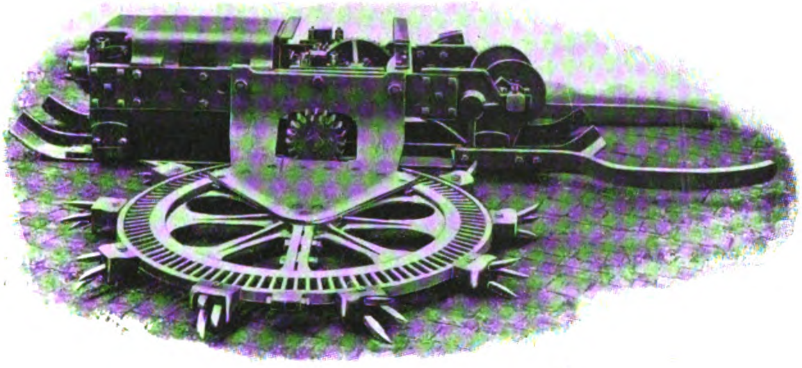


Fig. 3. The Single-motor Diamond Disc-type Electric Coal Cutter.

this therefore there is offered particular scope for the British manufacturer, whose experience in the ways and means of economically mining coal is unique.

The following are some details and illustrations of the work done by the Diamond Coal Cutter Company, Wakefield, the well-known specialists in this class of machine, whose work is known in every part of the world where coal-mining is engaged in. It is important to note that the Diamond Company build both electric and compressed-air machines; they also standardize chain machines and disc-cutters. It is well known to practical coal-mining men that no one type of coal-cutter will successfully serve all conditions; as a consequence it may be accepted that the experience of this company with its various types of machines is the more valuable.

With the exception of the Dominion Coal Company, of Glace Bay, longwall coal-cutters do not appear to have made much progress in Canada up to the present, but there is undoubtedly a large field for their introduction, and the improvements made in this class of machinery during the last few years in this country will, it is hoped, lead to an increased demand from the Canadian coal fields.

The particular type of coal-cutter used by the Dominion Coal Company is shown in Fig. 4. It is a compressed-air disc machine, and the illustration shows the machine in actual service at the coal-face just starting an undercut.

Other longwall cutters are illustrated in Figs. 1, 2, and 3. The first shows the two-motor type Diamond disc-cutter, which is at the present time more largely used than any other longwall machine. The second, Fig. 2, illustrates an overcut type Diamond chain machine driven by electricity; and Fig. 3 shows a single-motor electric cutter of the disc type. The electric cutters are fitted with either direct-current or alternate-current motors as required.

The Diamond Coal Cutter Company are also the sole manufacturers of the Blackett patent underground conveyor, which has created a revolution in the system of working thin seams in the British Isles, and which is being taken up by many of the leading collieries on the Continent. The illustration, Fig. 5, is from a photograph taken

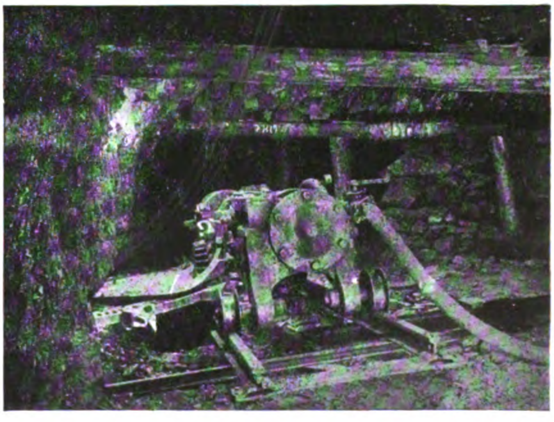


Fig. 4. Diamond Coal Cutter as used by the Dominion Coal Company, Canada.

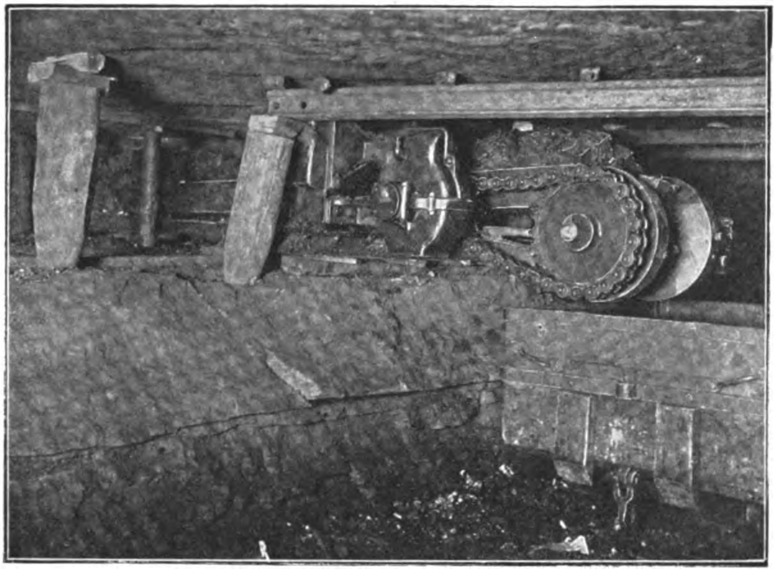


Fig. 5. Blackett Underground Electric Coal Conveyor.

below ground, showing the delivery end of an electrically-driven conveyor. The photograph is taken at the main gate end, an empty tub having just been brought into position beneath the delivery end of the conveyor. There are already seams being worked in Canada in which the "Blackett" could with advantage be introduced. The saving of labour by such a plant in connection with a coal-cutter is remarkable, and in a country where labour is scarce this is of considerable importance. Not only, however, is the question of labour involved, but the general safety of the mine is improved owing to the rapid advance of the coal-face, and a given output can be produced from a very much smaller working area than is necessary by hand.

A very popular machine is the Diamond patent percussive heading machine, which is driven by compressed air. This little header is eminently suitable for work in Canadian mines at the present time. It has many advantages over other machines of its kind, more especially as regards the patent valve, which acts in a positive manner and ensures against the piston getting jammed; the swivelling bracket is an advance on the usual worm and sector method usually employed for this purpose, since the blow is taken by trunnions in the direct line of thrust and the patent detachable bits and drill head have proved of the greatest service in practical work. The Diamond header is lighter than most machines of its class and, being less complicated in detail, is not so costly as the majority of percussive channelling machines.

The Company also make a specialty of electrical and hand mining drills, and of electric detail apparatus for mine circuits.

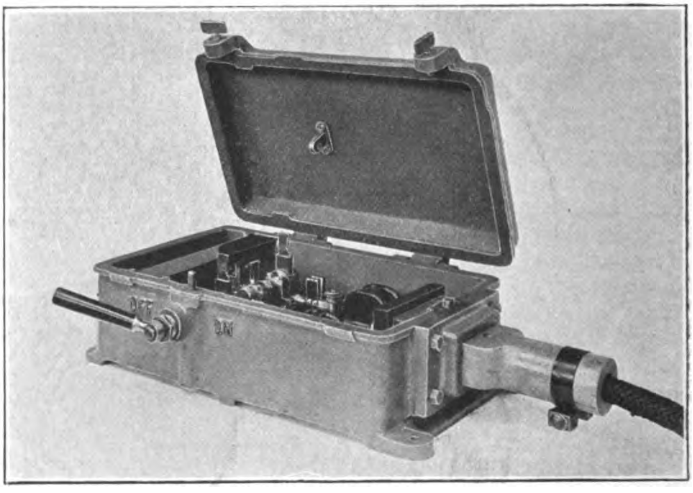


Fig. 6. Double-pole Gas-proof Switch and Cut-out Box for Mining Service.

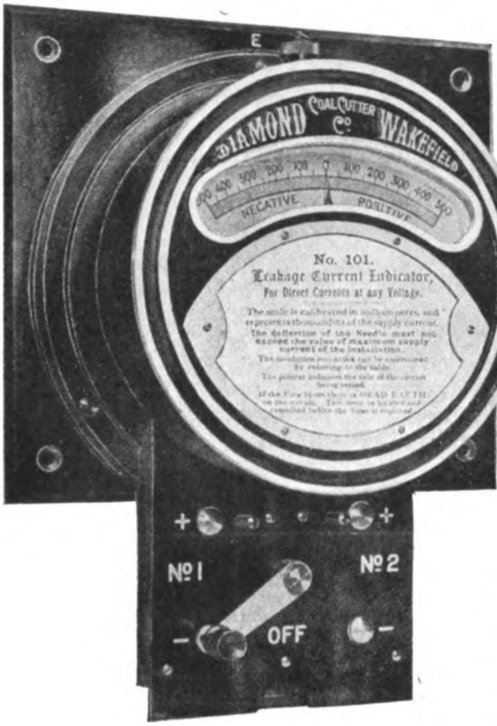

E
DIAMOND COAL CUTTER Co. WAKEFIELD
500 400 300 200 100 0 100 200 300 400 500
NEGATIVE
POSITIVE
No. 101.
Leakage Current Indicator,
For Direct Currents at any Voltage.
The scale is calibrated in milliamperes, and represents thousandths of the supply current.
The deflection of the Needle must not exceed the value of maximum supply current of the installation.
+
+
No 1
No 2
OFF
−
−

Fig. 7. Leakage Indicator for Mining Circuits.

A patent double-pole, gas and fool-proof switch and cut-out box for underground use is shown in Fig. 6.

This box is fitted with a detachable handle, which performs the functions of a key. When switched "off" the box automatically locks itself and the same happens when switched "on," and it is only by turning the handle into the vertical position that the box can be opened. The closing of the box also automatically locks the trailing cable adaptor. A device is also fitted which makes it impossible to switch "on" until the lid is closed and the live terminals are protected by a hood. The switch is gas and water tight and is in all respects in accordance with the Home Office Rules for the use of electricity in mines. Fig. 7 shows the Diamond Company's leakage indicator, which was introduced a short time previous to the publication of the Home Office Rules above referred to and wherein it is specified that the leakage current shall not exceed one thousandth of the maximum supply. The indicator reads direct in thousandths and at a glance it can be seen whether the insulation resistance of the circuit is in accordance with requirements. This instrument is adaptable for any voltage, and a card giving the insulation resistance in ohms for the various readings is supplied with each indicator.

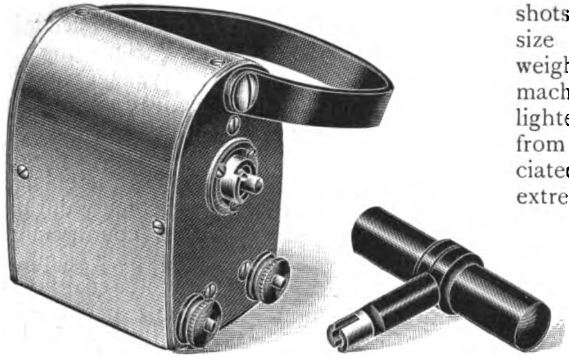
The extraordinary increase in the use of longwall coal-cutting machinery during the last few years in this country and on the Continent points to a similar activity in some of the remoter coal fields in the near future, and the experience of British manufacturers in this particular branch should direct the attention of Canadian mine managers towards the old country. The Diamond machines are largely used in France, Germany, Austria, and Russia; in Japan, in India, and in Australia.

* * *

The "Davis-Derby" Magneto Exploder.

The recent great development in the employment of shot firing by electricity in coal mines, in consequence of the introduction of new legislation, has had the effect of setting the manufacturers of such apparatus to work to design a generator which shall produce the necessary current of electricity to fire the shots with a minimum of weight and bulk, and it would appear that the well-known firm of John Davis & Son (Derby), Ltd., have justified their reputation in this direction. They have evolved a new magneto-exploder which they have named the "Davis-Derby" and which exhibits several distinctive and advantageous features.

The object of this invention is to provide a compact and efficient device for firing electric detonator fuses. It consists of a magneto or dynamo generator enclosed in a convenient case, the armature (preferably a simple bi-polar one) being driven through spur gearing by a ratchet device mounted on a shaft the end of which is squared or otherwise adapted to engage with a key or crank. The tedious process of revolving a cranked handle and pressing a button is displaced by a handle which works on a shaft supplied with a ratchet in front of the gear wheels. The gearing is necessary to obtain the high speed required at the armature. The armature, commutator, and gear wheels must all rotate together, so that when the operating



The "Davis-Derby" Magneto Exploder.

key is smartly turned through about half a revolution they will be driven through the ratchet up to the end of the movement of the operating handle, and they will then overrun the ratchet and rotate by their own momentum for a short time.

One of the generator brushes is connected to the frame and the other to an insulated terminal and the ratchet shaft, which is in electrical connection with the frame and which carries a projection or arm which at a certain point comes in contact with a fixed metal stop in electrical connection with the other terminal. Thus no current flows through the external circuit until the projection on the ratchet shaft comes against the contact stop, and this is at the end of the stroke of the hand key when the armature is rotating at its highest speed and the output of the generator is at its maximum voltage.

The "Davis-Derby" exploder is constructed either for high or low-tension fuses. It is also constructed in various sizes of which the following are the leading particulars:

The largest will fire up to twenty shots in series, size 7½in. high, 5in. wide, 7¼in. long; weight 15lb.

The smaller size, as illustrated, is constructed to fire four shots through fifty yards of twin wire, the size being 4½in. high by 3½in. by 4in.; weight under 4lb.

The latest and the smallest exploder will fire two shots through 50 yards of twin wire, the size being 3½in. high by 2½in. by 2¼in.; weight 1lb. 14½oz. The last-mentioned machine is said to be the smallest and lightest magneto exploder yet produced, and from all reports it appears to be well appreciated by the shot-firer on account of its extreme portability.

Electrical Appliances for Motor Vehicles.

The accessories and specialities placed on the market and in process of development by the Gratze Patents and Engineering Syndicate, Ltd., London, are too numerous to review in detail. Chief among these may be mentioned the speed indicator for vehicles or boats, and the revolution indicator for stationary purposes. Of exceptional interest are the portable electric lighting sets for carriage, motor, and launch lighting. Each outfit includes two domed brass lamps, fitted with strong condensing lens and containing an "Osmi" filament lamp of high candle-power and small consumption. The current is supplied from an accumulator mounted in a small teak case and made non-spillable. The general form of the outfit is clearly shown in the illustration Fig. 1.

Another type of secondary battery is the Gratze improved Plantè ignition accumulator, Fig. 3. These cells are formed on an entirely new principle in which the "pasted" and "formed" plate methods are combined by forming the grids of lead and alloy in a special electrolytic solution. The result of this process is that plates are obtained

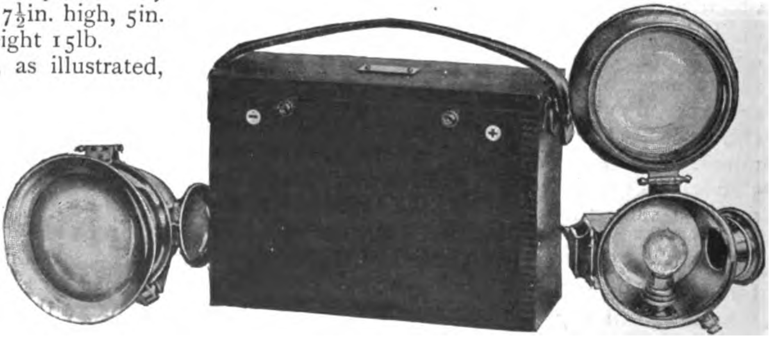


Fig. 1. Portable Electric Lighting Set for Vehicles.

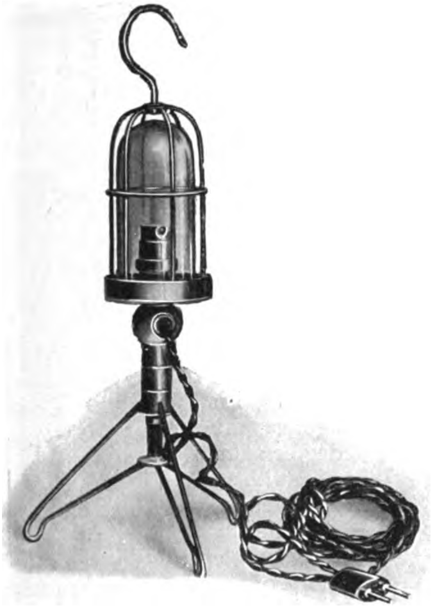


Fig. 2. Portable Hanging or Stand Lamp.

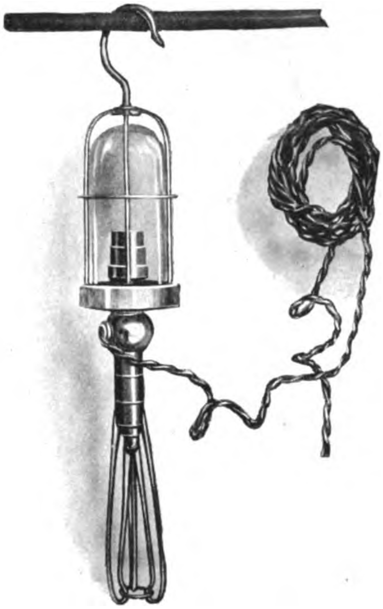


Fig. 4. Portable Hanging or Hand Lamp.

having a very high capacity, weight for weight, and at the same time they are very perfect mechanically, so that it is possible to discharge the cells at any rate without injuring the plates. This firm also make portable electric lamps for running in conjunction with these accumulators, and for fitting on the interior and exterior of broughams, motor-cars, vehicles, and launches; two of these are illustrated in Figs. 2 and 4.

The Gratze ignition apparatus for petrol engines, suitable for motor-car service and for stationary engine service, takes the form of a new synchronised distributor making a common supply of the high-tension terminal, so that only one coil is necessary, whereas hitherto it has been the practice to use four coils in conjunction with a four-contact commutator. The magneto generator is an improved type, and embodies an advance and retard mechanism. The armature is of the laminated type, and in the high-tension magnetos the secondary and terminal windings are both on the same armature.

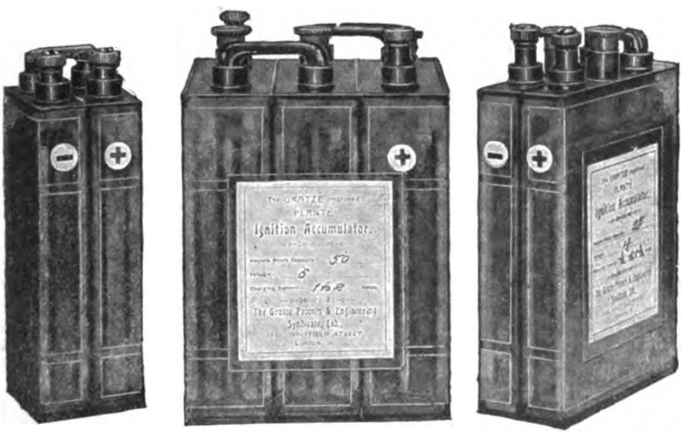


Fig. 3. Gratze Ignition Accumulators

An ignition apparatus combining a coil and spark detector complete with a high and low-tension distributor and advance and retard mechanism is supplied, all mounted in one case, as will be seen from the illustration Fig. 5, the idea being that, so far as petrol engines are concerned, the whole of the ignition mechanism shall be before the driver and every part accessible. The high-tension

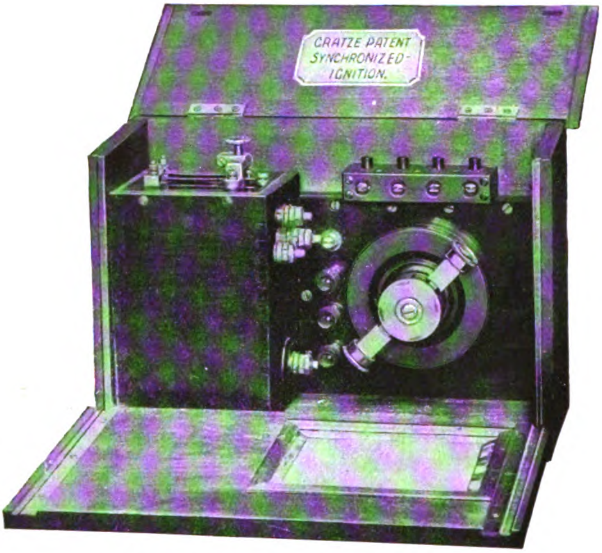


FIG. 5. GRATZE COMBINED IGNITION OUTFIT.

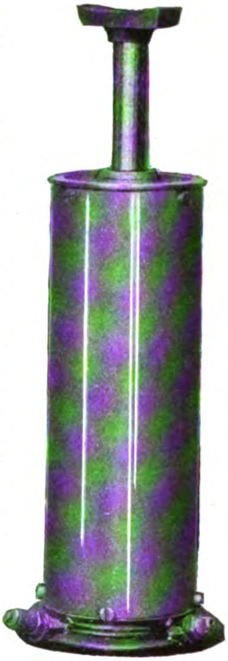


FIG. 7. PNEUMATIC JACK.

circuit is paralleled by the little vacuum bulb which serves to indicate whether the cylinder ignition is correct.

There is also an electric horn or syren, illustrated in Fig. 6, which gives a very loud resonant note, and which may be run from a 4, 6, or 8-volt accumulator. Apart from its use for motor-cars this appliance is exceedingly useful for signalling, or for use on the water.

An article worthy of note is the pneumatic jack, which is portable, and may be used for raising vehicles or machinery by simply applying air pressure to a valve (Fig. 7).

Another useful accessory is the gradiometer. This is a little apparatus which may be fixed to any moving vehicle or boat, and will either indicate the gradient on which the vehicle is travelling, or the swinging of the vessel. It may be also used for building purposes in place of the spirit level, as it indicates on the dial in figures the degree of incline with an accuracy not possible by the bubble of the ordinary level.

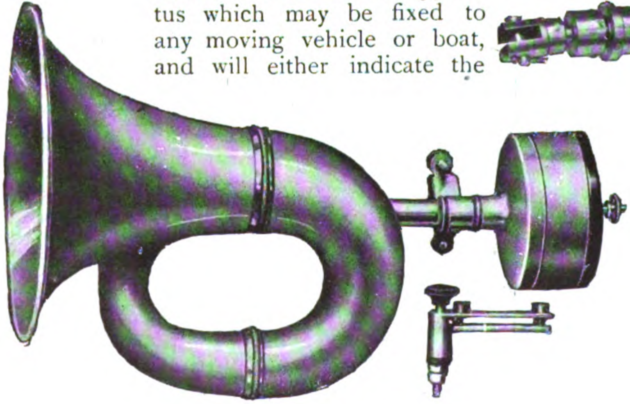


FIG. 6. ELECTRIC SYREN.

Having reviewed a few of this firm's accessories and specialities, it should be added that they make all types of the smaller grades of electrical apparatus and machinery, mechanical parts, especially those requiring precision and accuracy.

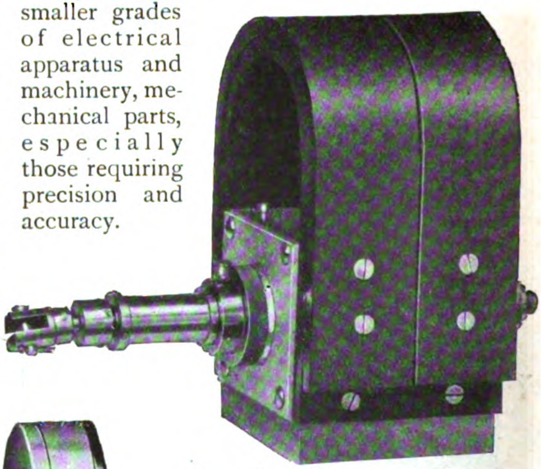


FIG. 8. GRATZE MAGNETO MACHINE.

The Gratze Works are centrally situated in the West of London, and are well equipped with modern tools for the rapid and accurate production of the above appliances and smaller classes of electrical machinery of every description.

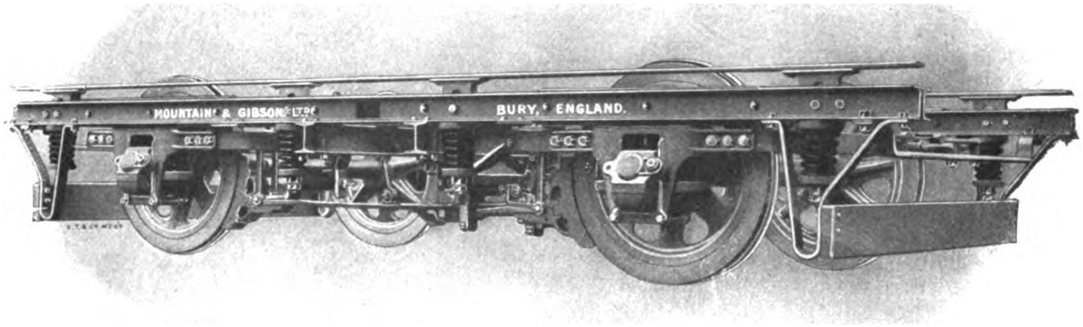


FIG. 1. FOUR-WHEEL RADIAL AXLE ELECTRIC TRAMWAY TRUCK.

Tramway and Railway Rolling Stock.

THE products of Messrs. Mountain & Gibson, Ltd., Elton Fold Works, Bury, Lancashire, in the way of electric rolling stock specialities are known in all countries where electric traction has come into use. Confining their business simply to this special class of work, it will be found that the several standard forms of trucks, cars, and electric vehicle equipments are each designed to fulfil the particular requirements of any traction system or locality.

In describing a few of the standard designs, those have been selected which should appeal with particular force to the Canadian buyer.

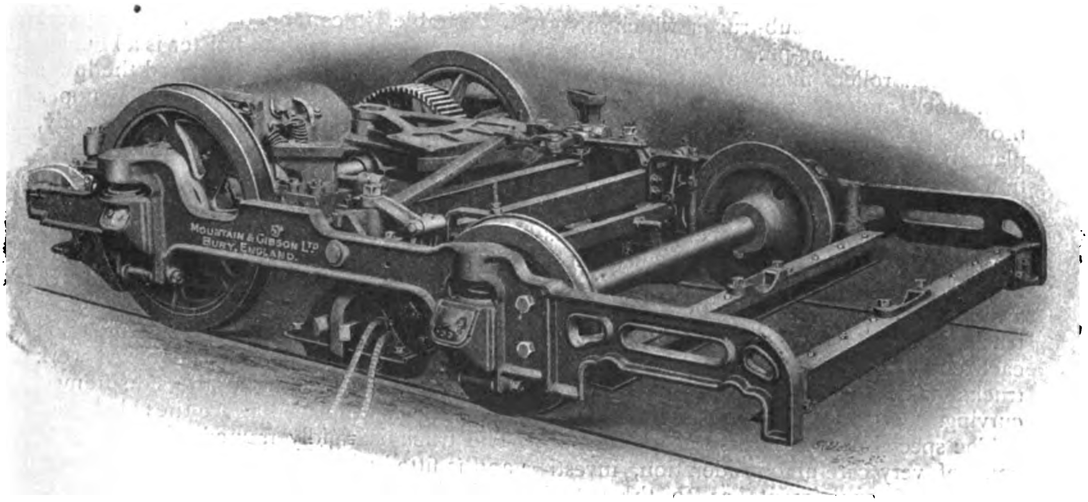


FIG. 2. CENTRE-BEARING SWING BOLSTER MAXIMUM TRACTION TRUCK, FITTED WITH ELECTRIC MOTOR, MAGNETIC BRAKE AND PLOUGH CARRIER.

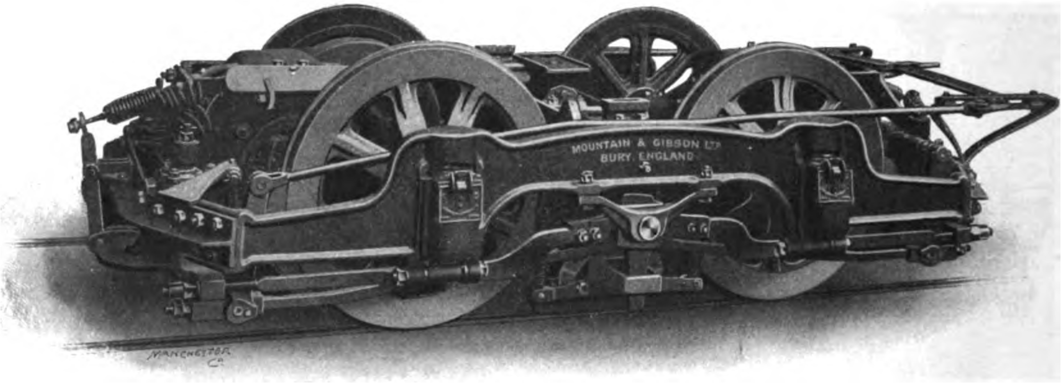


FIG. 3. CENTRE-BEARING SWING BOLSTER BOGIE TRUCK WITH DOUBLE MOTOR EQUIPMENT AND FITTED WITH MAGNETIC BRAKE.

The M.G. Improved Patented Four-wheel Radial-axle Tramway Motor Truck.

This has been introduced to meet the growing requirements for a truck with radiating axles, capable of supporting a car body longer than is used with the ordinary single-truck (four-wheel rigid wheel base truck). It is specially designed to run on sharp curves with a maximum of efficiency, as by the construction of the truck the wheels and axles are allowed to accommodate themselves to the curves. The truck consists of an intermediate frame which supports the car-body, special supports and spring compressors being provided for the purpose. The frame is carried upon two sub-trucks which pivot from their own king-pin, the weight being taken upon rollers fixed to the top of the horn block and working in oil baths upon bronze bearings, hardened steel rubbing plates being fitted to the underside of the frame to work upon the rollers.

The truck can be fitted with either chilled cast iron or steel tyred wheels; steel axles are provided made of special quality steel; improved brake rigging is provided and arranged for working from either end of the truck. A control arrangement is fitted at each end of the truck to ensure the sub-trucks taking a central position after curving.

The special design of this truck is the outcome of very careful consideration, investigation, and experiments as to the actual requirements for street tramway and light railway work, and embodies many essential points necessary for satisfactory running.

The M.G. No. 3-L Type Centre-bearing Swing Bolster Maximum Traction Tramway Motor Truck.

This truck, Fig. 2, has been specially designed to carry the heavier type of bogie tram-car in which a two-motor equipment is used. It is the latest development of a truck of this description, embodying the most up-to-date features. It is fitted with a swing bolster, which is supported by springs carried upon a spring plank, which is suspended by swinging links from the transoms. The side frames of the truck, as illustrated, are of cast steel. The transoms are of channel steel, and the bolster is of cast steel, or, and if desirable, it can be built up from steel plates. Attached to the bolster is a knuckle or hinge, upon which is mounted the lower half of the centre swivel plate. The upper half, which is attached to the car-body, works upon this, and is fitted with a king-pin at the fulcrum point.

The truck is fitted with driving wheels of a large diameter, with trailing or pony wheels of small diameter, in order to give the maximum traction effect, and the truck is so designed as to allow of about 65 per cent. of the weight of the car being upon the driving wheels. The axle boxes work within machined horns in the side frames, and springs are placed above the axle boxes. The truck is rigidly framed with end sills, and is fitted with an improved arrangement of brake rigging. The particular arrangement shown on the truck, as illustrated, has been specially designed for use in combination with the magnetic brake, it being so arranged that when the magnetic brake comes into action the brake levers are automatically put into use. The truck can be fitted with either chilled iron or steel tyred wheels, and the axles are made of special quality steel.

In the truck illustrated a plough carrier is shown for use with the underground conduit system, but in systems where the overhead line is in use, this plough carrier is dispensed with, and an end sill provided as a brace for the trailing end of the truck.

M.G. Improved Equal-wheel Type, Centre-bearing Swing Bolster Tramway Bogie Truck.

This truck is of the centre-bearing swing-bolster type and has been designed for supporting heavy car-bodies of the bogie type, especially where four-motor equipments are used. It is specially suitable for heavy service and for high-speed travelling.

The details of this truck are similar to the maximum traction trucks, excepting that all the wheels are of equal diameter, and the truck is so arranged that motors can be placed on each axle and suspended at each end.

The brake rigging is of improved form. Either chilled iron or steel tyred wheels can be used, and the axles are made of special quality steel.

The truck as illustrated in Fig. 3 is fitted with magnetic track brake, but can be also fitted with mechanical track brakes when required. An arrangement can be fitted whereby the magnetic track brake can be operated mechanically if desired.

M.G. Electrically-driven Sweeping, Watering and Sprinkling Cars.

These cars are built in varying designs, and can be either constructed as watering cars only for sprinkling and rail flushing, or as combined sweeping, watering, and sprinkling cars, or as sweeping cars only.

The watering can be done either by gravity or by pressure, and the cars can be either of the open type or fitted with canopy, covering in the tank and other work. They are built with a tank capacity of from 1500 to 3000 gallons, and can be fitted upon ordinary four-wheeled under-carriages or upon bogie trucks, according to requirements.

The watering car illustrated in Fig. 4 is of the covered-in type for sprinkling the roads and for rail-flushing, the sprinkling being done by pressure, and in this instance the

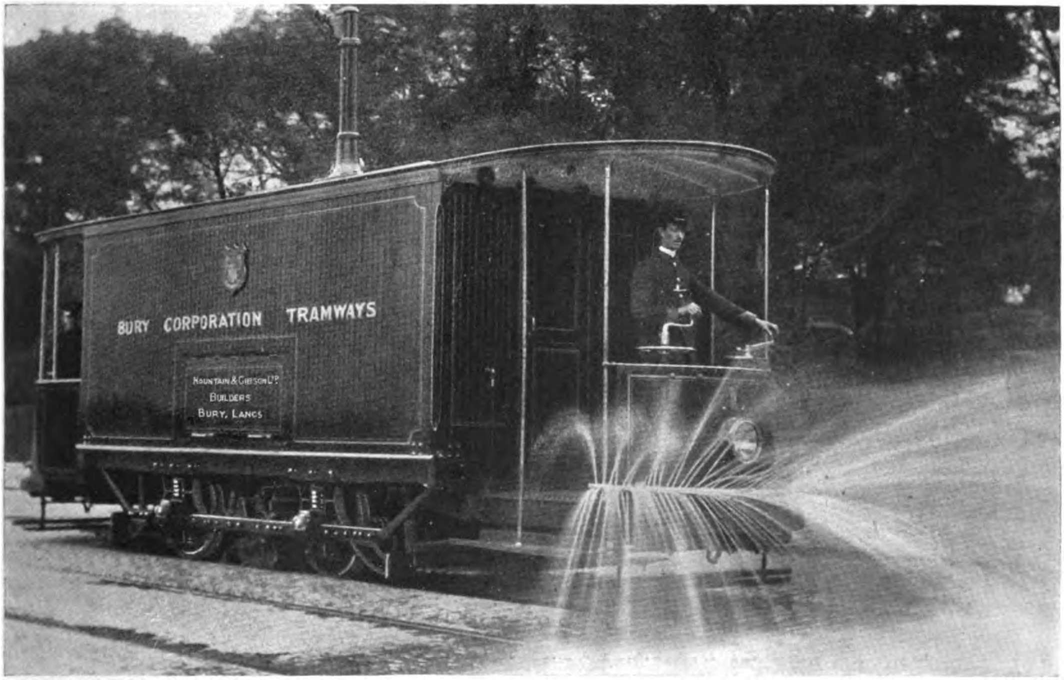


FIG. 4. RAIL-FLUSHING AND SPRINKLING CAR.

pressure is obtained from an air-compressor driven by a separate electric motor, and placed in a convenient position within the body of the car. The tank capacity of this car is 1800 gallons, and the spread of water can be arranged to cover a distance of from 50 to 70ft. in width.

The other illustration, Fig. 5, represents a combined sweeping, watering, and rail-flushing car of the open type, so arranged that the sprinkling can either be done by gravity or by pressure. The sweeping brushes are placed at both ends of the car, and arranged for cleaning the roads and sweeping away either snow, slush, mud, &c. The brushes are driven by a separate electric motor in a space arranged below the tank, driving the brushes by means of countershaft and gearing. The brushes are adjustable in height, controlled from the platforms, and can be put in and out of gear as required. In the watering and sweeping cars the undercarriage is of a special construction, substantially built to carry the heavy weights put upon them, and to meet the conditions required. The main framing of the car is built up of steel sections, and arranged to carry the working parts. The cars are fitted with efficient wheel brakes, and can also be provided with either magnetic or mechanical track brakes when required.

Portable Engines.

THE well-known firm of Clayton & Shuttleworth, Ltd., engineers, Lincoln, have been engaged in building engines and machines for considerably over half a century; and it has always been their aim to improve and perfect as far as possible those features which have already proved so successful. They have placed nothing upon the market which has not satisfied their experts that it will satisfactorily perform the work for which it has been designed, the result being that

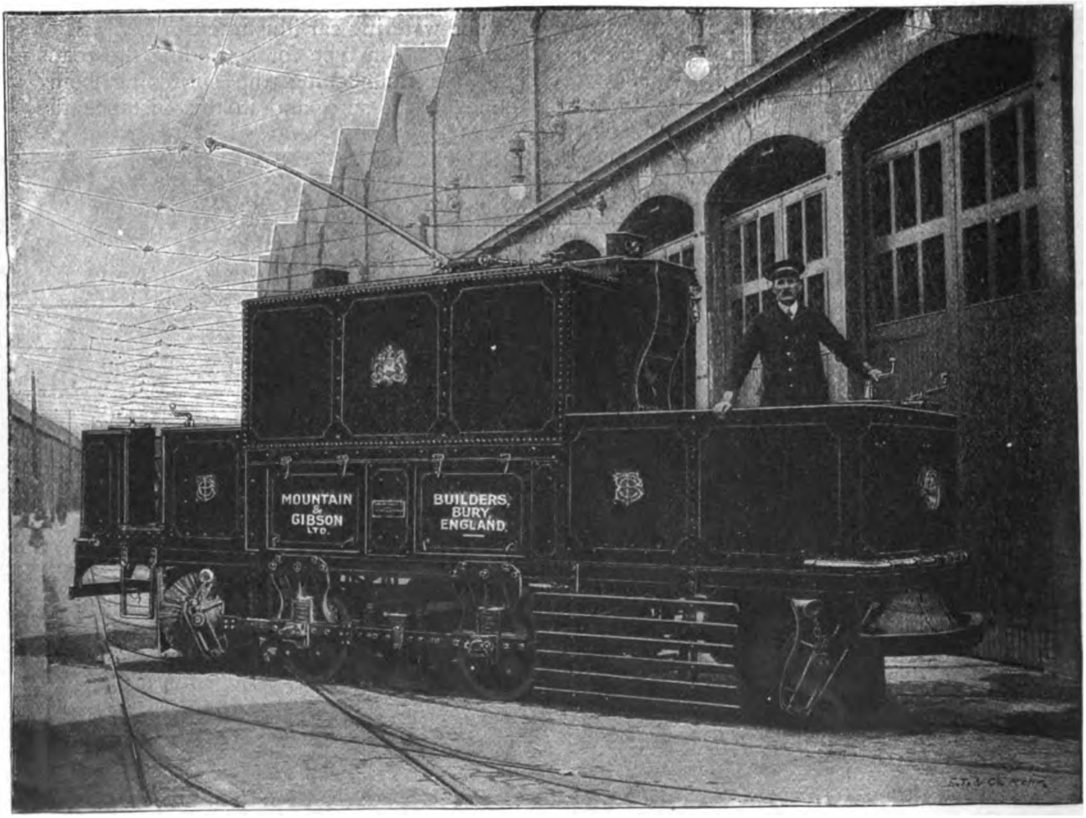


FIG. 5. COMBINED ELECTRIC TRAMWAY SWEEPING, SPRINKLING AND RAIL-FLUSHING CAR.

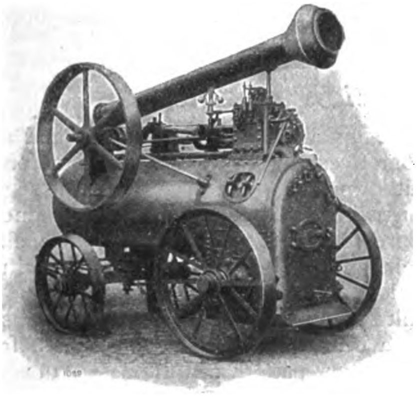


FIG. 1. SINGLE-CYLINDER PORTABLE STEAM ENGINE.

they are generally acknowledged as makers of what are probably the finest portable steam engines and thrashing machines obtainable, and this is equally true of their traction engines, road locomotives, undertype engines and boilers, road rollers, centrifugal pumps, stackers and elevators, chaff cutters and maize shellers. It is worthy of note, as well as being a significant fact, that they have made and sold upwards of 100,000 engines and thrashing machines alone since the commencement of their business.

The portable engines are so simple in construction that they can be managed by any person of average intelligence. The single-cylinder type, Fig. 1, is exported to almost every country in the world, and it is giving entire satisfaction whilst working under all possible variations of climate and conditions. This engine is in general use for driving thrashing machines, grinding mills, pumps, or for all of the varied uses to which an engine of this class may be applied. Due proportion between the engine and the boiler is a point of supreme importance, and special care has been taken in order to secure this desired end. When running at a moderate speed the engine can easily develop three times its nominal power, whilst the boiler has ample heating surface for generating steam in excess of the requirements, with easy firing and consequent economy of fuel. The slide valve eccentric sheave is adjustable, so that the cut-off may be varied between one-quarter and five-eighths of the stroke, in proportion to the power to be given off by the engine. The effect of this is a further economy in fuel. It is also so

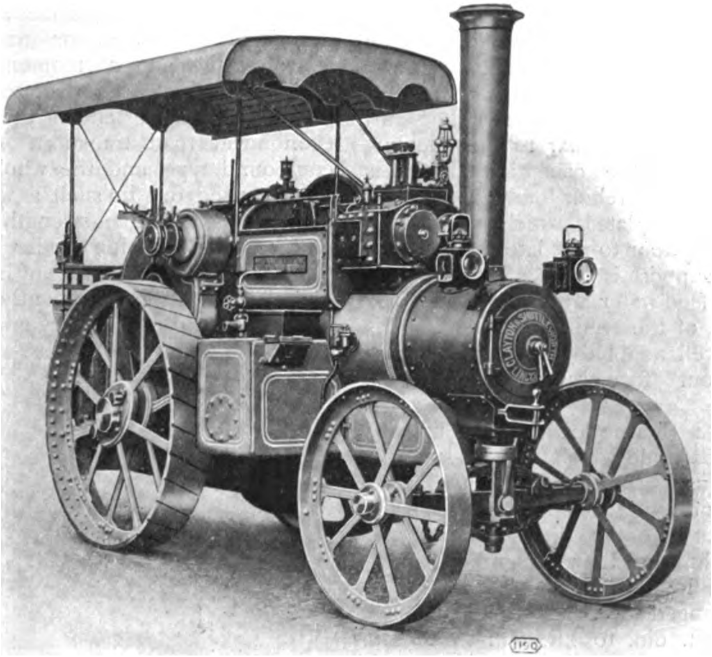


FIG. 2. COMPOUND ROAD LOCOMOTIVE. THE "LITTLE HERCULES."

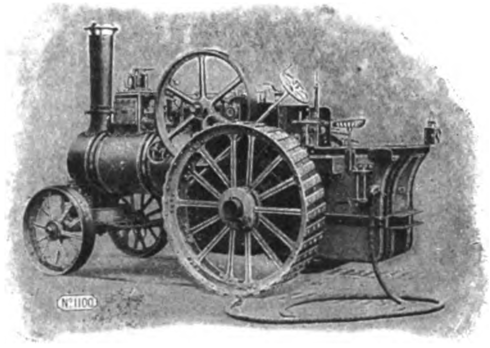


FIG. 3. SINGLE-CYLINDER AGRICULTURAL TRACTION ENGINE.

arranged that the engine may be run in either direction, whilst in all cases where regularity of speed is a necessity, such as for electric lighting or where the load is extremely variable, Messrs. Clayton & Shuttleworth recommend that these engines be fitted with their automatic expansion gear. In this two separate valves are employed, each actuated by its own eccentric. The first, or main, valve controls the admission of the steam; the expansion valve regulates the cut-off and is in turn controlled by a sensitive governor of improved construction, which promptly responds to the slightest variation of the load. By this means the speed of the engine is automatically kept constant.

Another type of this engine is the semi-portable, which is similar to the one just mentioned, with the exception that it is mounted at the firebox end on a strong ashpan of steel plates, which is provided with a hinged door to regulate the draught. The front support is built of steel plates, and forms a feed-water tank, into which the suction pipe of the feed-pump is led. This engine is well adapted for districts where skilled labour for erecting cannot be obtained.

Clayton & Shuttleworth, Ltd., make a log-burning portable, which has been specially designed for use in the Colonial "hinterland" where no good roads are available and skilled labour cannot be obtained. For easy transport its weight is less than that of the ordinary "Colonial" log-burner. The firegrate is specially arranged for taking rough wood or logs from 3ft. 6in. to 4ft. 6in. in length, according to the size of the engine. This type of "portable" is also constructed with double cylinders, as well as on the compound system, and can be fitted with a straw-burning fire-box where such fuel is desirable.

Traction Engines.

The agricultural traction engines and road locomotives built by Messrs. Clayton & Shuttleworth, Ltd., are claimed to be so well designed that for efficiency and economy in working cost they are unexcelled. Their improved single-cylinder agricultural traction engine, Fig. 3, which is the result of an experience covering upwards of half a century, has been constructed from entirely new patterns, in the design of which all the best features have been embodied. These engines, which are also built on the compound principle, can be had in various sizes to suit the purchaser's requirements. They are particularly adapted for hauling or driving thrashing machinery, steam ploughing, transporting agricultural produce or other heavy loads. The road locomotives, both single-cylinder and compound, are well designed and finished; their chief characteristics being great strength combined with simplicity in construction and economy in working.

The latest example of this firm's work in the traction engine department is the "Little Hercules" steam motor tractor, Fig. 2, which at the present moment is receiving much attention from contractors, carriers, and others interested in the question of economical road transport. It is of the compound type, and the whole design has been carried out in such a way as to give the greatest possible strength and hauling power while keeping under five tons in weight. The cylinders are of large diameter, and the engine is sufficiently powerful to take a full load up ordinary gradients on the

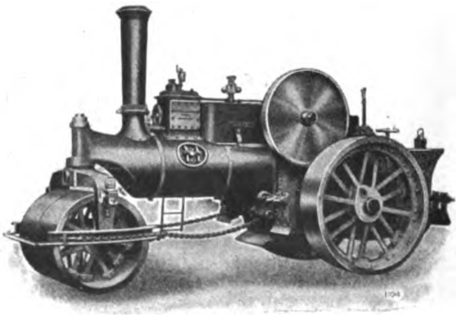


FIG. 4. STEAM ROAD ROLLER.

fast gear. The boiler has an ample margin of safety, and is stayed to withstand a working pressure of 180lb. per square inch. The flywheel is made extra wide to receive a driving belt, thus enabling the tractor to be used for stationary work as well as for haulage. The feed pump, instead of being actuated direct from the crankshaft as formerly, is now driven by gearing, thus reducing the speed of the ram, considerably minimizing the wear, and rendering the pump far more effective. The road wheels are of unusually large diameter, and double driving pins are provided in the naves to ensure increased safety in hill climbing. Additional water tanks of large capacity are provided to allow for extra long journeys without stoppages for fresh supplies. The coal bunker capacity has also been considerably increased and various other improvements have been introduced.

In actual working this little engine has given entire satisfaction, and at a large limestone quarry in Devonshire it displaced six horses which had cost, in corn alone, no less a sum than £4 10s. per week, or £234 per annum. The working cost of the tractor, which in all other respects had the advantage, was only £1 7s. per week, or £70 odd per annum. It is also worthy of note that steam-propelled vehicles secured the whole of the prizes for loads over three tons at the recent important trials of the Royal Automobile Club.

In the matter of weight the "Little Hercules" is decidedly superior to the various forms of steam lorry, the latter with its load being supported entirely on four comparatively narrow wheels of small diameter, whereas the weight of the tractor and loaded wagon is equally distributed over eight travelling wheels, and consequently, undue wear of the roads is avoided. Another decided advantage lies in the fact that the load is separate from the tractor, so that two or three additional trailers may be employed, thus allowing the engine to be fully occupied in other directions during the time the work of loading and unloading is proceeding, which cannot be the case with the motor wagon. A further strong point in favour of the "Little Hercules" tractor is that should there be any sinking of the wheels when travelling over soft land, it can be speedily uncoupled from the load and allowed to run forward to some convenient spot, where by means of the winding drum and wire rope provided, or by a length of chain from the drawbar, the trailer and its cargo can be drawn forward upon the firm ground. It is admirably suited to those who are on the look-out for a light tractor which combines economy with strength, durability, simplicity and utility.

The road rollers made by this firm are of special interest to municipalities, urban and rural councils, and other road authorities. They can be had in various weights, with or without the patent scarifier. Clayton & Shuttleworth's road roller with sleeping van and water cart is a most convenient set for the repairing of roads. A large number of these are at work throughout the United Kingdom, whilst a great many have been supplied to Austria, Hungary, Belgium, France, Spain, Cuba, Germany, South Africa, China, and other parts of the world. Clayton & Shuttleworth, Ltd., are also builders of undertype engines and boilers, both on the single-cylinder and compound systems. No effort has been spared in order that these shall be up to date in every respect. They are fitted with the firm's improved vertical heater, by means of which the temperature of the feed water is raised to nearly boiling point. This effects a considerable saving of fuel, and also relieves the boiler of local strains which would be set up by a cold feed.

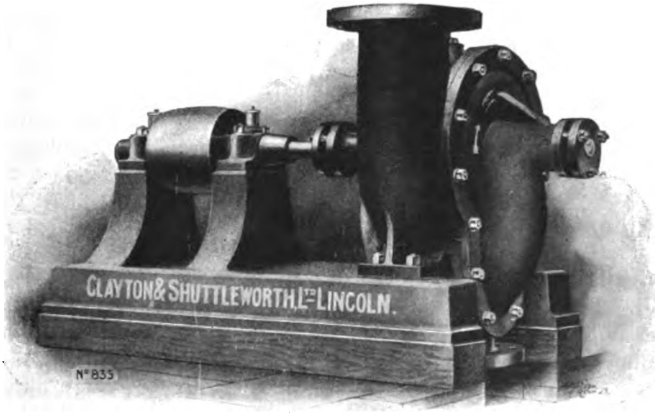


FIG. 5. AGRICULTURAL TYPE OF CENTRIFUGAL PUMP.

Centrifugal Pumps.

In view of the extended sphere of usefulness of centrifugal pumps it is not remarkable that they have become so popular. At low and moderate lifts they are particularly efficient in dealing with large quantities of water. The "Accessible" pump, made by Clayton & Shuttleworth, Ltd., is so simple in construction that the parts can be readily inspected, renewed or repaired. There are no valves which are liable to become choked, or barrels and plungers to get out of order. When dealing with turbid and gritty liquids, for which no other type would be suitable, this pump is at its best. It is splendidly adapted for the drainage of quarries, fens, and marshes, for irrigation in countries which are subject to prolonged drought, particularly in Australia, Egypt, and India. When high lifts demand it, it is necessary to obtain a high circumferential speed on the disc, and to meet these requirements this firm make their pumps in various sizes. The "Accessible" pump attains a very high degree of efficiency when working at such lifts as 20ft. and 25ft., and though there is little diminution in capacity up to 35ft. the volume of water raised by the pump is reduced to some extent where greater lifts must be dealt with. However, where the power required is only small, and economy is not a question of vital importance, a single pump can be relied upon up to 60ft. These pumps are built with single or double standards and bearings to the spindle. For small and moderate sizes for low lifts a single standard and over-hung pulley will suffice, but for, say, a 6-inch pump with 20ft. lift, double standards are desirable. Clayton & Shuttleworth's standard pattern is always arranged with vertical suction and delivery branches. These can, however, be arranged at any angle to suit the user's requirements. In cuttings and river banks considerable variation in the slopes is frequently met with, and to obviate this difficulty the "swivelling suction" pattern is particularly suitable. The firm also make a very handy form of portable centrifugal pump for irrigation, drainage, or contractors' work. Special care has been taken in its design, not only to make it easily transportable, but also that it may be applied to any kind of duty. For lifts of 100ft. and over these pumps can be arranged in series—two or more according to the height of the lift, as it is usual to allow one pump for each 50ft. of lift so as to ensure the maximum result.

Thrashing Machines.

In the manufacture of thrashing machines Clayton & Shuttleworth, Ltd., who were the first to introduce a thrasher with perfect apparatus for finishing the corn ready for market, may almost be said to lead the world. Much might be written of the innumerable ingenious and effective improvements they have from time to time introduced; many of these are of an exclusive character and not to be found in the machines of other makers, but considerations of space render it impossible to enter into details. Suffice it to say that three-quarters of a century of constant experiment and endeavour has rendered these machines as nearly perfect as human skill can make them, and that many thousands are now at work upon the world's largest harvest fields and giving the most unvarying satisfaction. It is particularly interesting to note the marked success which has attended the application of the electric motor to these thrashers, this being a form of driving for which they appear eminently suitable.

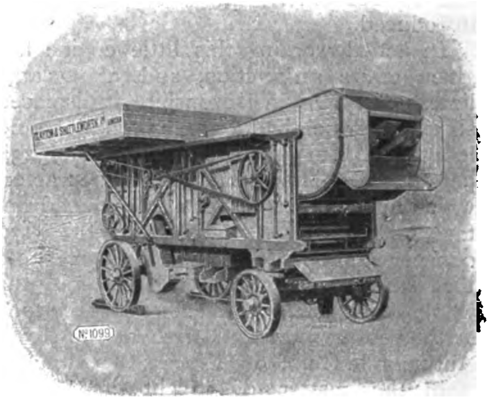


Fig. 6. Thrashing Machine.

Lifting Magnets.

Lifting magnets offer an expeditious means of transporting blocks, bars, rails, forgings, plates, tubes, castings, filings, &c., of steel, cast iron, or wrought iron. The lifting power of the magnets is but little

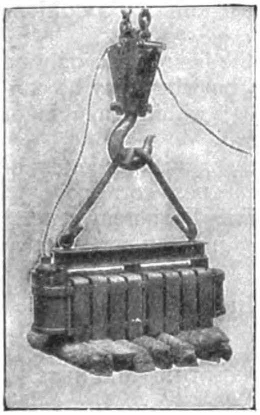


FIG. 1. LIFTING MAGNET HANDLING PIG IRON.

affected by the temperature of the load up to 300deg. C., but beyond this point, it diminishes at an accelerated rate and ceases altogether at a temperature of from 600 to 700 deg. C. Messrs. Siemens Bros. Dynamo Works, Ltd., whose works are at Stafford, have made a special feature of the design of lifting magnets to suit various conditions. These magnets are supplied either with fixed or movable or adjustable pole pieces. Magnets with fixed poles are provided either with round or oblong poles. The round form is particularly suitable for lifting solid blocks of iron, complete machines, stiff iron sheets, armour plates and so on, while the oblong form offers special advantages in connection with the lifting of a number of iron bodies, such as billets, rails, angle iron, channel iron, and so on. Long bodies are preferably handled by means of two or more magnets suspended from the crab of the crane. Long magnets are provided with movable poles of ⊓ shape or ᗰ shape. In the latter case each pole can be separately adjusted so as to obtain as large a contact area as possible on bodies of curved or irregular shape.

For places where the material is to be conveyed above the heads of workmen, Messrs. Siemens supply lifting magnets fitted with an electrically operated grab, Fig. 3, which embraces the material and prevents it from falling in the case of anything going wrong with the lifting magnet.

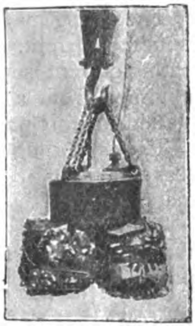


FIG. 2. LIFTING MAGNET HANDLING SCRAP IRON.

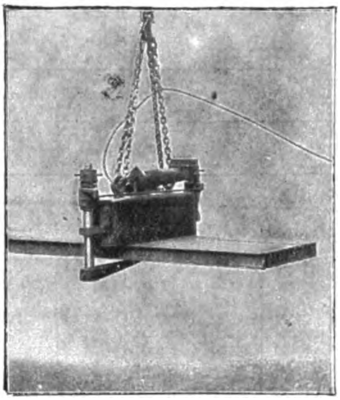


FIG. 3. LIFTING MAGNET FITTED WITH SAFETY GRAB.

TABLE I.

Type.	Form of pole.	For solid bodies of cast steel.		Energy consumed. Approx. watts.	Net weight Kgs.
		Safe lifting power* (about half the max. magn. pull.) Tons.	Min. thickness of metal.** Cms.		
K280 o	Round.	0.2	1.7	60	40
K280 i	,,	0.5	2.2	100	70
K280 ii	,,	1.5	4.4	100	250
K280 iii	,,	3.5	5	145	330
K281 iii	Oblong.	2.5	2.5	470	270
K282 vi	Oblong; the poles are of ᗰ form and adjustable.	1.4	2.6	570	330
K282 viii		1.8	2.6	660	420
K282 x		2.3	2.6	800	510
K282 xii		2.7	2.6	900	600
K283 viii	Oblong; each pole can be separately adjusted.	3.0	2.6	880	420
K284 iv	Oblong; arranged in form of horse-shoe.	6.5	‖ 6	570	1200
K284 vi		14.0	§ 8	1100	2140

* For perfectly flat unplaned surfaces.

** The minimum thickness of cast iron must be twice that given in the column; the lifting power for cast iron is from 10 to 20 per cent. less than for cast steel.

‖ Min. width of material 57 cms.

§ Min. width of material 100 cms.

The lifting magnets are energized by continuous current. In the case of an alternating-current supply, continuous current is obtained from a small motor-generator installed for this purpose.

The preceding table (I.) gives the chief technical data of the Siemens lifting magnets.

The results of some interesting tests on the maximum magnetic pull which these powerful electro-magnets are capable of exerting under various working conditions are given in Table II.

It is obvious that the figures can only be taken as approximate, but they may be considered as holding good within a margin of 20 per cent. up or down.

In this table the distinguishing letters of the several types of magnets correspond to those included in Table I. wherein general descriptions of the forms of the respective magnets are given.

TABLE II.

RESULTS OF TESTS ON THE LIFTING CAPACITIES OF SIEMENS LIFTING MAGNETS.

The figures given represent the maximum magnetic pulls observed in the tests. The dashes in the various columns indicate that the magnet is not suitable for the particular purpose.

Type.	Lifting capacity of one magnet.											
	Solid material with flat surface.								Rolled Iron.			
	Cast steel unplaned.					Cast iron planed.						
	Magn. pull in kgs. at distance of mm.					Magn. pull in kgs. at distance of mm.			No.	Shape and Size.	Length m.	Total weight kgs.
	0	1	5	10	20	0	1	5				
K280 o	400	340	100						—	—	—	—
K280 i	1000	850	250						—	—	—	—
K280 ii	3270	2300	600	200	70							
K280 iii	7500	5600	1200	500	150	6100	4300	750				
K281 iii	4900	3700	1400			4600	3500	1300				
K282 vi*	2800					2600	2000	820				
K282 viii*	3700					3500	2650	1100	10	o 55mm. dia.	6.5	1200
K282 x*	4600					4400	3300	1400				
K282 xii*	5500					5200	4300	1600				
K283viii**	6500					6200	4700	1900				
K284 iv	13000	10000	7000						50 3† 20‡	o 20mm. dia. o 135 ,, ,, [34 × 36 × 5mm.	4.5 6.45 6 0	550 2200 440
K284 vi	28500	22000	15400						250	½″ gas tubes	5.0	1500

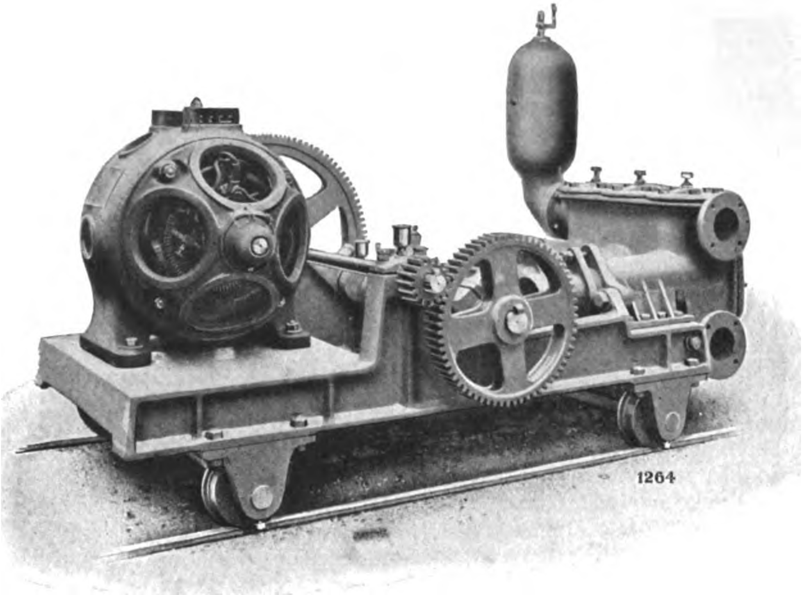
Type.	Lifting Sheet-iron with two electro-magnets: each sheet of iron is 2m. long and 1m. wide. Thickness of sheets.											
	1mm.		2mm.		3mm.		6.5mm.		10mm.		20mm.	
	No. of Sheets.	Total weight kgs.	No. of Sheets.	Total weight kgs.	No. of Sheets.	Total weight kgs.	No. of Sheets.	Total weight kgs.	No. of Sheets.	Total weight kgs.	No. of Sheets.	Total weight kgs.
K280 o	—	—	—	—	—	—	—	—	—	—	—	—
K280 iii	19	300	13	400	9	420	4	400	2	310	1	310
K281 iii	11	170	8	250	5	230	3	300	2	310	1	310
K282 viii	14	220	9	280	5	230	3	300	2	310	1	310
K283 viii	17	265	11	340	8	370	3	300	2	310	1	310

* The pole pieces have an adjustment of 40mm. in an axial direction.

** The pole pieces have an adjustment of 30mm. in an axial direction.

† The current employed in this test was heavier than would be permissible for continuous service. This increase in current is permissible for intermittent working.

By increasing the current it was possible to lift 30 lengths of iron of a total weight of 660kgs. This increase in current is only permissible for intermittent working.



A Portable Electrically Driven Pumping Set.

Single-Phase Motors.

THE illustration on this page shows one of the Rhodes single-phase, R.X. type, motors coupled to a three-throw pump. The motor will be found especially suitable for the Canadian market owing to its extreme simplicity and exceptional characteristics. It is capable of starting against full load with a current consumption of only approximately full-load value, or it can be arranged to start with double full-load torque with only approximately double full-load current. In addition to this the motor requires no external starting switch whatever, with the exception of an ordinary double-pole switch, the motor being, in itself, entirely automatic in its operation, and therefore especially suitable for putting into the hands of inexperienced users. An additional feature of this type of machine is the fact that the makers are able to construct it for reversing by means of a switch only, and therefore it is eminently suitable for direct connecting to the gear of a lift or crane or for other purposes where a dead weight has to be started up against in either direction. In the case of a crane requiring careful adjustment, as in a foundry, this motor, by means of an ordinary tramway type controller, can be readily controlled to the fullest possible desired amount. It is manufactured by Messrs. Rhodes Motors, Ltd., at Doncaster, and has the further essential advantage of being supplied at prices which compare very favourably with those of the ordinary slip-ring type of motor without starter.

◆

Portable Hoists and Transporters.

THE rapid and efficient handling of materials in factories, workshops, foundries, &c., has of late received much attention, it being realized that the old-fashioned hand pulley-blocks and appliances are much too slow and inefficient. Numerous types of pneumatic and other mechanical appliances have been constructed, but these are rapidly giving way to the newer forms in which the electric motor takes the active part. When made in accordance with up-to-date crane practice, these small electric hoists are undoubtedly the most rapid and economic machines which can be employed for this purpose. They work at very high speeds, and can be combined with existing girders and runway tracks as easily as an ordinary lifting trolley, the only special provision necessary being the overhead wires for supplying the current.

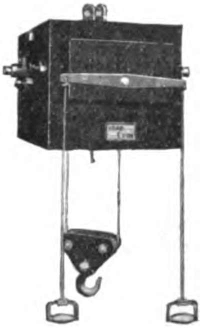


FIG. 1. ELECTRIC HOIST FOR GIRDER SUSPENSION.

After several years' experience in the manufacture of this class of hoist, Messrs. Kramos, Ltd., of Bath, have now standardized designs for completely automatic conveying plants for handling loads from 56lb. to 3 tons at high-lifting and travelling speeds.

The illustrations, Figs. 1 and 2, show examples of the several forms which are a special feature of the output of Messrs. Kramos. The first illustration shows a hoist for suspension from any existing girder or hook, and if desired the same can be attached to an ordinary trolley carriage. The hoisting motion is governed by two depending ropes with handles marked "up" and "down" respectively. The second illustration shows an electric transporter designed for transporting cement skips as used in harbour construction. In this case both the hoisting and travelling motions are operated electrically. The attendant travels with the load in the cab provided, and in which are placed the necessary controlling and brake handles. In all Kramos hoists spur-gearing with machine-cut teeth is used throughout, this being universally acknowledged as the most efficient method. The electric motors are of first-class British make, and the controllers are of special design fitted with Kramos patent resistances. The winding drum is machine grooved, and the best steel wire rope is employed for the lift. The brake action is particularly sensitive, and loads can be lowered to a nicety. This precision in adjusting rise and fall of the load is a most important point when the hoists are used for serving machine tools, &c. The brake is combined with the hoisting controller, but provision is made whereby it can be operated by a separate hand lever, and loads can therefore be lowered by gravity.

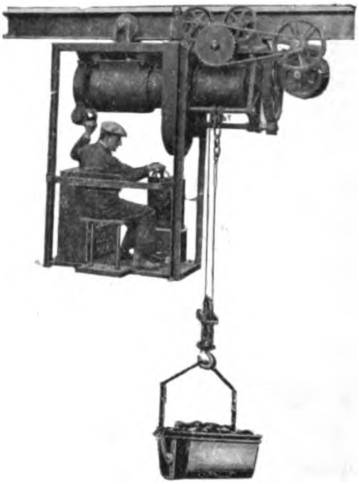


FIG. 2. ELECTRIC TRANSPORTER.

Messrs. Kramos also manufacture an entirely automatic conveyor for use in mills, factories, &c. No attendance at all is necessary. The hoist is started by means of a push-button and at once starts hoisting; immediately the cage reaches the frame provided for it the hoist travels along a girder, and on reaching the end of the journey it is again stopped automatically and at once lowers the load on to a special table. It then returns without stopping to its original position, and this cycle is continued without pause until the hoist is switched off by means of a second push-button. The machine will execute the whole performance (lifting height being 30ft., travel 50ft., lowering distance 6ft.) in about 39 seconds, with a load of 1½cwt. It will be seen, therefore, that the design of this class of apparatus has reached a very advanced stage, and certainly the performance of this particular equipment leaves little to be desired in the way of speed and economy.

Portable Electric Tools.

Another well-known speciality of Kramos, Ltd., is the manufacture of portable

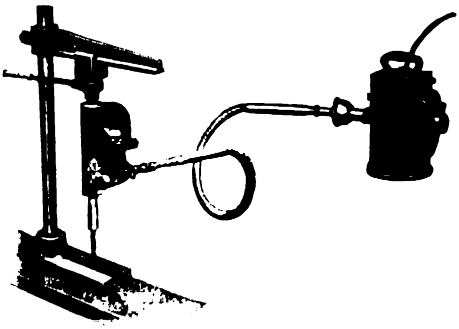


FIG. 3. MOTOR AND FLEXIBLE SHAFT WITH DRILL HEAD.

electric tools, of which the drills illustrated in Figs. 3 and 4 are typical. The utility of these electric appliances is now so universally acknowledged that any general comments under this heading are unnecessary. As with Kramos hoists, the leading features of these drills are simplicity combined with reliability. Armatures of great length, gearing with teeth of ample width, long bearings, and reliable switch and brush-gear make these machines in reality portable "machine tools," capable of standing the rough usage to which electric drills are subjected in workshop and shipyard use. Four types of self-contained machines are made capable of drilling $\frac{3}{8}$in., $\frac{1}{2}$in., $\frac{3}{4}$in., and $1\frac{1}{4}$in. respectively in mild steel, and for larger work equipments consisting of motor, flexible-shaft and drill-press are supplied. Magnetic pillars for use with electric drills and drill-presses, to obviate the necessity of clamping down the drilling pillar by means of bolts, are also manufactured.

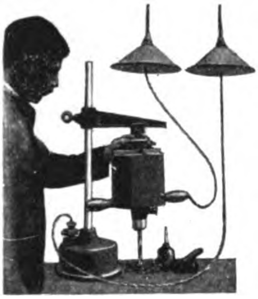


FIG. 4. PORTABLE ELECTRIC PILLAR DRILL WITH MAGNETIC GRIP ATTACHMENT.

Economies in Office Routine.

THE continual striving after newer and more economical methods of manufacture induced by present-day competition is closely reflected in the many improvements constantly being made in the administration of the offices of leading manufacturers. Down to the minutest detail all records receive the close personal attention of the principals, and no trouble is spared to reduce the routine work to an absolute minimum. To accomplish this end modern office equipment is installed, and to ensure its systematic working long and careful study is made of the most efficient methods of organization.

From a most humble beginning improvements have been effected one after another, until to-day the market offers a variety of equipments, of which perhaps the most important are those arrangements for dealing with the filing of correspondence, since this is a matter affecting the whole staff, and the necessity for immediate reference to correspondence is ever present. An examination of modern methods shows that all the practical manufacturers of these office systems have arrived at one fixed rule, the only difference being in their application of it. The broad axiom on which all modern filing methods are based is that every regular correspondent or every subject matter must be allotted its own filing cover, into which all the papers bearing on that head are collected together; thus rendering it possible at any time for a business man to hold in his hand a complete record of all his transactions with one client without being hampered by irrelevant papers. When it is remembered that business can never be transacted with more than one client at a time, whether a letter is being dictated or a conversation being held, it will be quite obvious that this rule, the outcome of many years' experience of competitive makers, is fundamentally correct; it only remains to select a suitable application of the principle to the particular needs of the individual.

Recognising the disadvantages arising from the keeping of papers loosely, several attempts have been made to introduce a simple flat apparatus for use individually; this has been successfully achieved by the Stolzenberg Patent File Company, of London, whose product is remarkable for its simplicity, cheapness and reliability. Their file consists of a folded sheet of strong manilla containing an unobtrusive apparatus lying perfectly flat when empty and gradually increasing with its contents, never occupying any appreciable room of itself. It exercises a perfectly reliable grip and allows papers to be added or withdrawn from any portion of the file without deranging the remainder of the contents.

In the Stolzenberg system of filing this file is applied individually, *i.e.*, one is allotted to every regular correspondent. They are stored alphabetically in specially designed cabinets, the latter being constructed on the building-up plan to permit of extensions being made in any quantity in any direction, thus ensuring the exact proportion of the installation to the requirements of the customer. These cabinets, Fig. 2, are constructed in small sections, each one containing a frontless

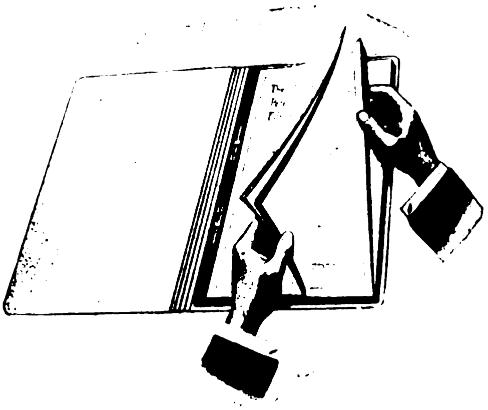


Fig. 1. The Stolzenberg File.

tray closed by a hinged lid hanging from the cabinet itself; the lid automatically rises to a horizontal position on drawing forward the tray, and at once displays the whole of the contents.

In order to still further facilitate reference a simple system of classification by colours is introduced; the files are manufactured in six sharply contrasting tints, which are allotted to the leading sections of a business, the most usual being the geographical allocation: thus red files might be allotted to London clients, blue to Provincial, yellow to Colonial, green to Continental, &c. Then to refer to the file of "Brown, of Glasgow," search is limited to the blue files in drawer B, or for "Jones, of Montreal," to the yellow files in drawer J. As each drawer contains an average of twenty files and search is limited to one-sixth, it is therefore necessary to examine not more than three or four files to find the one required. The lids of the drawers are clearly labelled as to their contents, and as many drawers as are required are allotted to each letter of the alphabet.

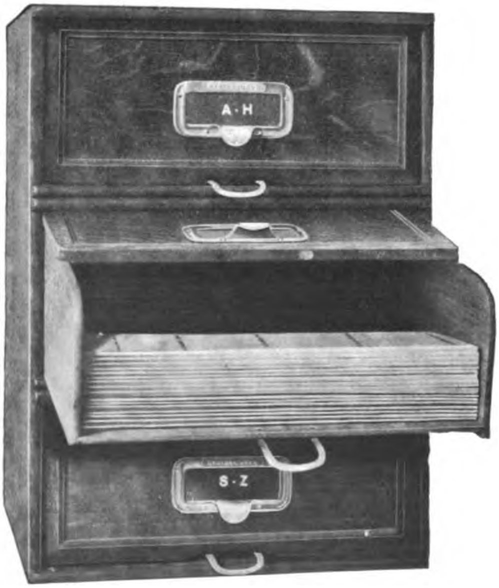


Fig. 2. The Stolzenberg Filing Cabinet.

The simplicity and adaptability to every requirement of this system has earned for it a leading place amongst business men. The Stolzenberg Company numbers amongst its satisfied clients some of the largest and most influential business houses in this country.

The patent files are applied to a thousand and one uses besides the systematic filing of correspondence. Documents of all kinds, printed matter, newspaper cuttings, &c., are easily kept by this means, though, perhaps, the greatest use after the one enumerated above is as catalogue covers, in which capacity the files are gaining a wide popularity. For this purpose they are made in beautiful art shades, of a special grade of manilla, and artistically printed in colours. They present a most distinctive and pleasing appearance.

Instead of issuing the large bound volume with which we have become familiar, firms dealing with a large variety of goods print their catalogue in a number of small sections or in leaflets, and only send to each enquirer those leaflets or sections dealing with the goods in which he is particularly interested at the moment, and, perhaps, a short *résumé* or index of the remainder. As a result a great saving of time is effected on the part of the recipient, who greatly appreciates such an effort to assist him; beyond this the firm secures enormous economies in printing and postage. A further advantage which this system offers over the bound book is the ease with which catalogues in the hands of clients can be kept right up to date. Leaflets or booklets dealing with the latest productions are despatched ready perforated to holders of catalogues, with the request that they will be filed with the remainder, which is always done by any interested recipient. The file is also sometimes used to contain the loose sheets of a tender, and to secure for that tender immediate recognition, as the distinctive

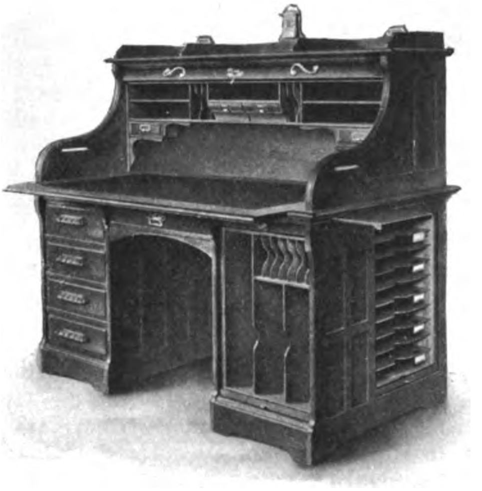


FIG. 3. A STOLZENBERG DESK.

appearance of one of the files is at once noticeable.

The Stolzenberg Company also manufacture on a large scale many other fitments for office and library, of which perhaps the most distinctive is their series of roll-top desks and tables, which have been constructed to a special design of their own and embody some most unique features, of which the most notable is the pull-out writing top, an arrangement whereby all darkness of working surface is obviated in a roll-top desk. Drawers are replaced in one of the pedestals by two roller shutter fitments, which add very considerably to the utility of the desk; this feature is also added to their writing tables.

It would be as well for all those writing for a descriptive catalogue of the company's filing system to make at the same time a request for a copy of the booklet "Distinction in Desks," which deals fully with the modern features of office furniture.

The Stolzenberg Company has now a very wide circle of clients both amongst commercial men and those engaged in civil and military administration throughout the whole of our Empire. The company's head office is at 50-53, Bishopsgate Street Without, London, E.C., and they have established branches in Glasgow, Newcastle-on-Tyne, Manchester, and Bradford.

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The Sheffield Canadian Engineering Company.

THOUGH Canada holds particularly strong views as to the development of her own manufactures, and undoubtedly she will some day occupy a foremost place among the manufacturing countries of the world, her general development at the present time is so extremely rapid that it is quite impossible for the Canadian engineers to manufacture sufficient machinery to meet with the needs of their country. This being so, British engineering manufacturers have an excellent opportunity to secure to themselves a footing in this, probably the most rapidly-growing market in the world.

The British manufacturers have always, more or less, had agents in the Dominion, and in some few instances established representatives, but for the most part the representation—if it could be so called—has been effected by the Canadian and American agents, who frequently handle innumerable lines of the same material, lines actually in competition with one another.

We have to call our Canadian readers' attention to a new organization known as the Sheffield Canadian Engineering Company, which has been established recently in Toronto. The company has been organized by T. W. Sheffield, A.M.I.E.E., A.M.I.M.E., who was responsible for opening the branch offices and showroom and carrying out the administration in the interests of Messrs. the British Thomson-Houston Company, Ltd., and Messrs. Crompton and Co., in the North of England. Mr. Sheffield is assisted by Mr. W. T. Brawley, who until recently was connected with the Russian Government Dockyards, and also by Mr. R. G. Banks, his late assistant at Messrs. Crompton & Co., Ltd., in the North of England.

The Sheffield Canadian Engineering Company has secured the sole agency for Canada for the manufactures of many noted British firms. Among the firms they will represent are:

Messrs. Gilbert Arc Lamp Company, Ltd., of Chingford;

Messrs. Simplex Conduits, Ltd., of London;

Messrs. Imeson Bros., Finch & Co., of Middlesbrough;

Messrs. Hudson Bowring, Ltd., "Tramway Lifeguards," Manchester;

- Messrs. Hughes & Sterling, the makers of the Sterling Destructor for incinerating town refuse;
- Messrs. Kramos, Ltd.;
- Messrs. Bullivant & Co., Ltd.;
- Messrs. Cundall, Sons & Co., Ltd.;
- Messrs. Rennie & Co., Shipbuilders, Greenwich;
- Messrs. Tasker & Son, of Andover, traction engines and agricultural implements;
- Messrs. W. B. Haigh & Co., Ltd., woodworking machinery;
- Messrs. Watson, Laidlaw & Co., centrifugal machinery;
- Messrs. Campbell, Morton & Co., of Glasgow.

For most of the above firms the Sheffield Canadian Engineering Company have secured the sole agency for the whole of Canada, and they will also be the sole representatives in the Dominion of Messrs. Wassermann & Co., of London, for the sale of Castolin, for which there is a large field in Canada in its application in brazing cast iron, thereby abolishing the great trouble of broken castings.

It is a noteworthy fact that the Sheffield Canadian Engineering Company handle entirely British manufactures, and this fact, in view of the strong competition of the United States for the Canadian trade, is the more calculated to help both them and the people they represent.

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Conduit Improvement.

In the history of conduit construction there is no side issue which has been pursued with the close and concentrated attention and the pertinacity which have been devoted to that difficult problem—electrical continuity.

The reason is not far to seek, since the great advantages of an efficient fitting of this kind are at once apparent. Greatly increased pressures of supply, combined with the severity of competition from rival illuminants, notably incandescent gas (it will be conceded that this competition at the present time is particularly severe), not only as regards the cost of light supply, but especially under the heading of installation cost, have pressed the demand for a simple and effective, but inexpensive, conduit system to a positive necessity.

Whilst screwed conduit work has come to be recognized, and is generally accepted and used, as the ideal system where the question of first cost is of secondary importance, electrical development must be seriously hampered in that area to which the station engineer and the trade at large must look for the improved load factor of the future—that sea of small and medium-sized residential property and commercial property which accounts for probably 80 per cent. or more of the revenue-earning property. Incandescent gas remains supreme in that area to the detriment of electrical development; and whilst no conduit system is available which combines adequate mechanical protection with a low installation cost and unquestionable electrical continuity, *i.e.*, electrical safety, that state of affairs must continue. These are ever present and pressing considerations which have kept both experts and amateurs concentrated upon the subject of electrical continuity, as is evidenced by the innumerable devices which have actually been placed upon the market, and the still more numerous devices which have been consigned to the scrap heap.

Going to early history we find Bathurst, the accepted pioneer in conduit matters in this country, pursuing this subject—we have on record various devices of his, in which, however, he cannot have seen a satisfactory solution of the problem, since none of them made a public appearance. We also find various patents covering devices of this kind from Mr. L. M. Waterhouse and many others. The subject has, in fact, never been allowed to rest, and yet it is fair to contend that to-day no device is available in which confidence can be placed.

Credit for the best earlier effort must be given to Mr. Bayliss, who, some few years ago, marketed the "Bayliss" grip fitting, which device was promptly followed by a somewhat obvious copy placed upon the maket by another maker. The originality and value of both devices may be judged by the fact that neither patent stood the test of time.

Summarising the numerous efforts which have been made, there is found one inherent and universal weakness in the fact that their authors rely for electrical continuity upon a close mechanical contact between two even

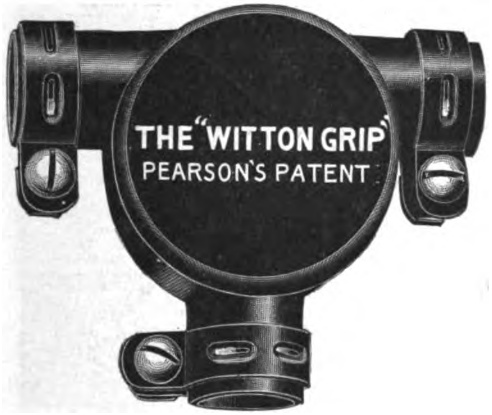

Fig. 1. Improved Conduit Grip.

surfaces. Whilst in theory these expectations may be justified, in practice they have proved useless. The reason is not far to seek. The natural variations in diameter and shape of tubes, which in their manufacture are unavoidable—slight variations as they may be—the irregular shapes resulting in handling, and in particular the cutting of tube, are all-important factors, and none of the devices available to-day meet these difficulties. There is a further all-important consideration which perhaps better still illustrates the weakness of these devices—the necessity of removing the enamel before electrical continuity can be hoped for. This difficulty alone places these articles at the mercy of the unreliable workman, and experience has shown that the workman cannot be relied upon to take this precaution. Again, with all and sundry of the fittings available to-day installation cost is exceptionally high, since none of them are of sufficiently simple construction to be of practical use, and to admit of reduced installation costs. In some cases screwed fittings are employed which, again, frequently are of the next larger size to that of the tube which is installed; other devices of elaborate construction, and, of necessity, costly in manufacture, are used; the cost of material is thus added to very considerably, and with some of these methods the cost of installation is quite on a par with the cost of installing screwed conduit.

What is required, and what experts and amateurs have aimed at for many years, is a conduit system which not only provides absolute electrical continuity, but which, as regards cost of installation, is roughly on a par with ordinary socket-joint material. The new device which the Armorduct Manufacturing Company, Ltd., London, are now placing before customers is claimed to fulfil these very essential qualifications. It is, perhaps, a somewhat disagreeable piece of irony that where the most concentrated attention of experts, extending over many years, has failed, the problem should ultimately be solved by one who must be considered almost an outsider so far as conduit construction is concerned. Mr. H. C. Pearson, the inventor of the device, worked out his idea in a spare moment. The Armorduct Company have decided to identify this device by the title: The Witton Grip (Pearson's Patent).

By reference to the illustration, Fig. 1, it will be noticed that the arrangement is at once simple, neat, and of undoubted mechanical and electrical value. A conduit fitting of the ordinary unscrewed type, and of the size ordinarily used, is slotted to part of its diameter, and a claw grip metal band, which is fitted with keen projections or teeth and which is held together by a binding screw, is laid around the fitting. The projections or teeth when the binding screw is tightened home firmly engage the tube, and in the closing and scraping movement which naturally results the enamel, which would otherwise prevent electrical continuity, is automatically removed. A mechanical contact of enormous strength is secured, and electrical continuity results as an absolute necessity, and cannot, in fact, be prevented by the most careless workman. The illustration shown should serve to convince the prospective user as regards mechanical strength and electrical continuity; it should further be recorded that the Faraday House Testing Institution has reported very highly in favour of the invention.

It is said that this fitting has been welcomed as a true solution of a difficult problem by leading central station and consulting engineers and by electrical contractors—opinions are all in favour of this device, and its true value may be judged by the fact that its use is admitted, and, in fact, advocated, by several municipal engineers who have refused to entertain any prior invention of its kind. The makers have made arrangements for the adaptation of all their standard conduit fittings to this principle, and at present all the ordinary fittings of this improved form are available for sale.

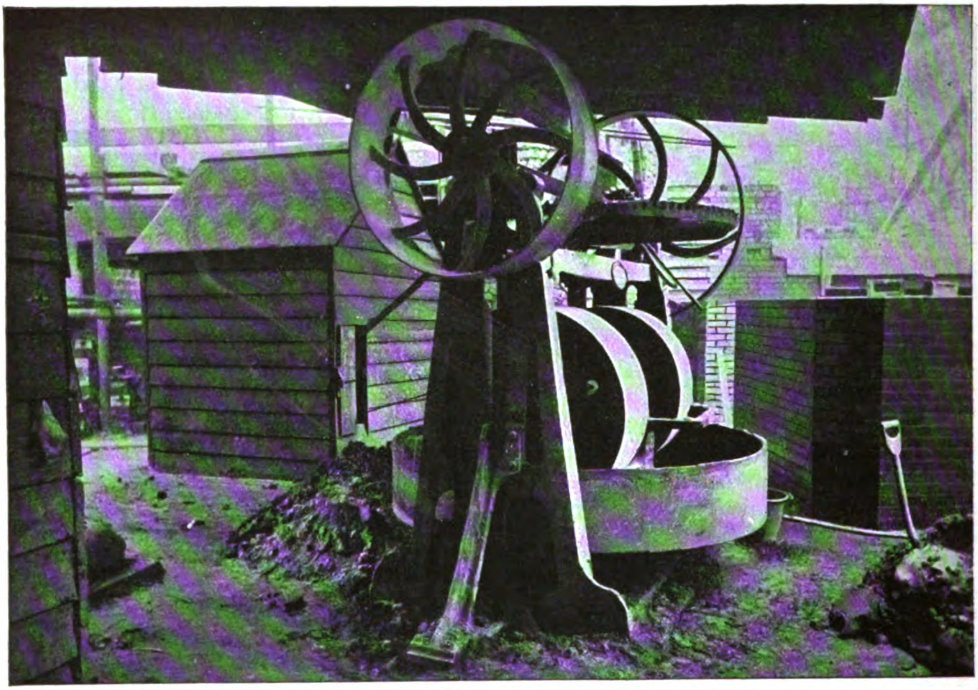

Fig. 1. An Electrically Driven Mortar Mill.

Motor Applications.

As affording examples of the great variety of the uses to which the electric motor is applied, the series of illustrations showing typical examples of machines equipped with driving motors by Messrs. Electromotors, Ltd., Manchester, is of interest. This well-known firm are specialists in the manufacture of motors and dynamos, and have made a particular study of their application to the driving of all classes of machinery, &c., one

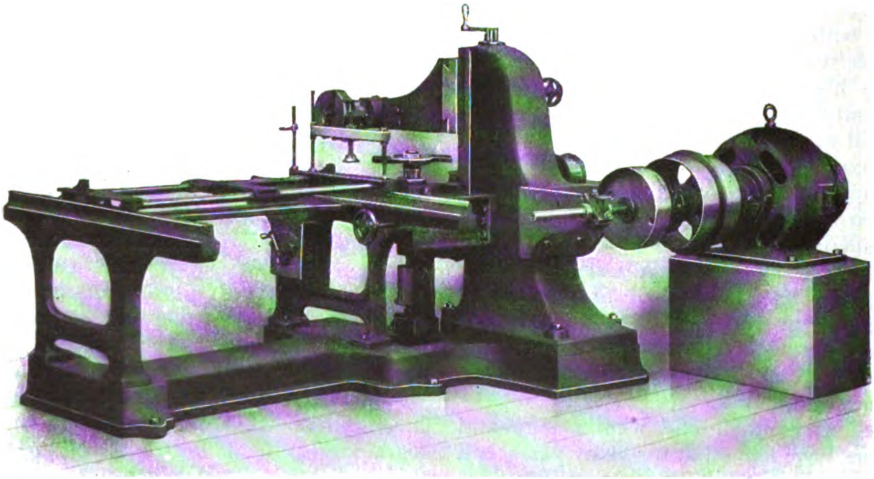

Fig 2. Tenoning Machine fitted with Direct Electric Drive.

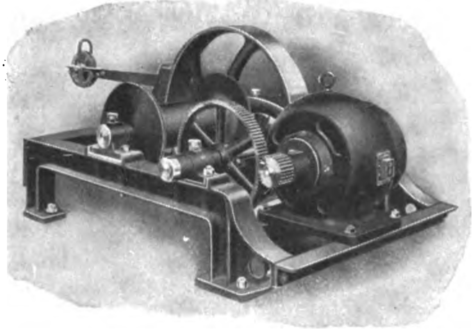

FIG. 3. ELECTRIC FRICTION HOIST.

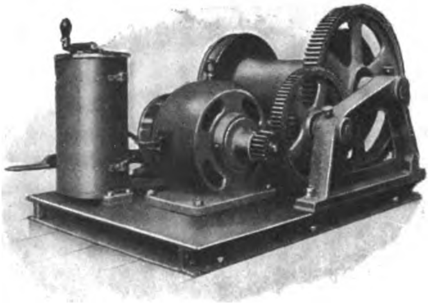

FIG. 4. ELECTRIC WINCH.

of the most important branches of their work being the supply of complete electrical equipments for the driving of works and factories.

Fig. 1 illustrates a mortar pan driven by belt from a motor which is fixed inside a shed for protection against the weather.

An illustration of an electrically-driven wood-working machine is shown in Fig. 2. In this case the motor is direct coupled to a tenoning machine. The illustration, Fig. 3, shows one of Messrs. Electromotors' standard specialities, namely, an electrically-driven friction hoist, a type which is invaluable to builders and for stores, &c., or for any place where light loads have to be manipulated quickly. For the handling of the heavier class of articles, and also for haulage work, &c., the company manufacture a direct-driven winch, of which an illustration is also given, Fig. 4. The motor is of the reversing type, and a reversing drum type controller is supplied.

The fifth illustration shows a standard crane motor fixed in position in the cab of a jib crane, and designed for quickness of manipulation of load and low running costs.

Some particulars were given in the last issue of THE ELECTRICAL MAGAZINE of the electric horse-clipper recently introduced by this firm. It will be seen from the illustration, Fig. 6, that this is a simple and handy appliance for which there is sure to be a

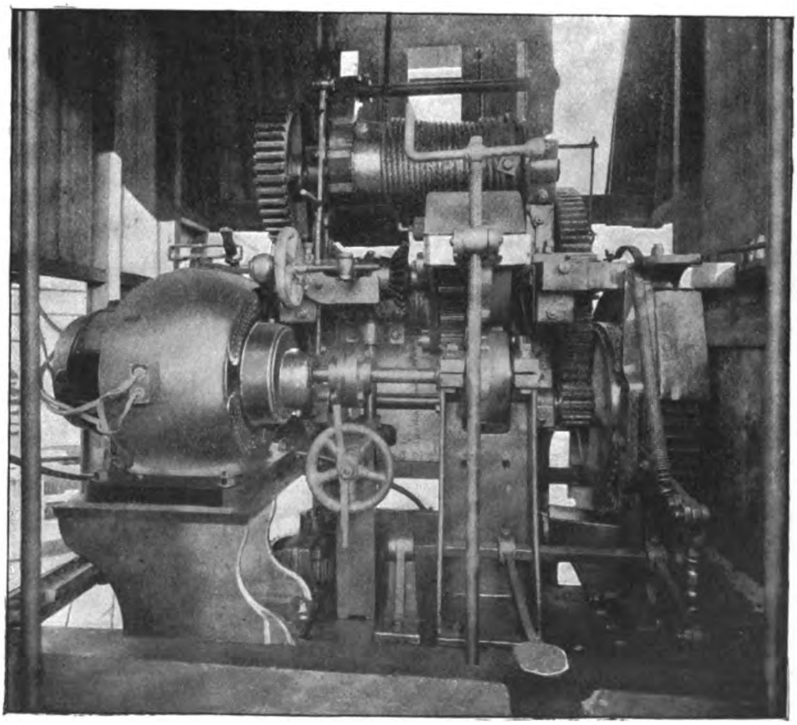

FIG. 5. ELECTRICALLY DRIVEN JIB CRANE.

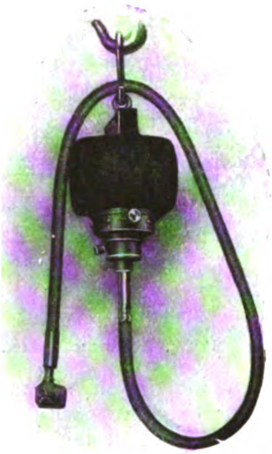

Fig. 6. Electric Horse Clipper.

large demand in Canada and other lands where agriculture and stock-raising are staple industries.

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Electric Cranes, Traversers, and Transporters.

A distinct speciality of electric hoisting tackle and traversing or conveying gears is made by Messrs. S. H. Heywood & Co., Ltd., of Reddish, near Stockport. The illustrations show to some extent the wide field which is open to electric plant of this description, and they further exhibit the degree of perfection which has been attained in their manufacture.

An electrically-driven traverser made specially for steel-plate works, for carrying trucks from one part of the works to another, is illustrated in Fig. 1. These traversers can be fitted with turntables and capstans if desired. The operator's platform is in the middle of the traverser, and raised above the floor level so as to afford the driver a view over the top of the trucks. A foot brake is provided so as to stop the traverser at any desired position, and stop blocks for the truck wheels are provided and operated by

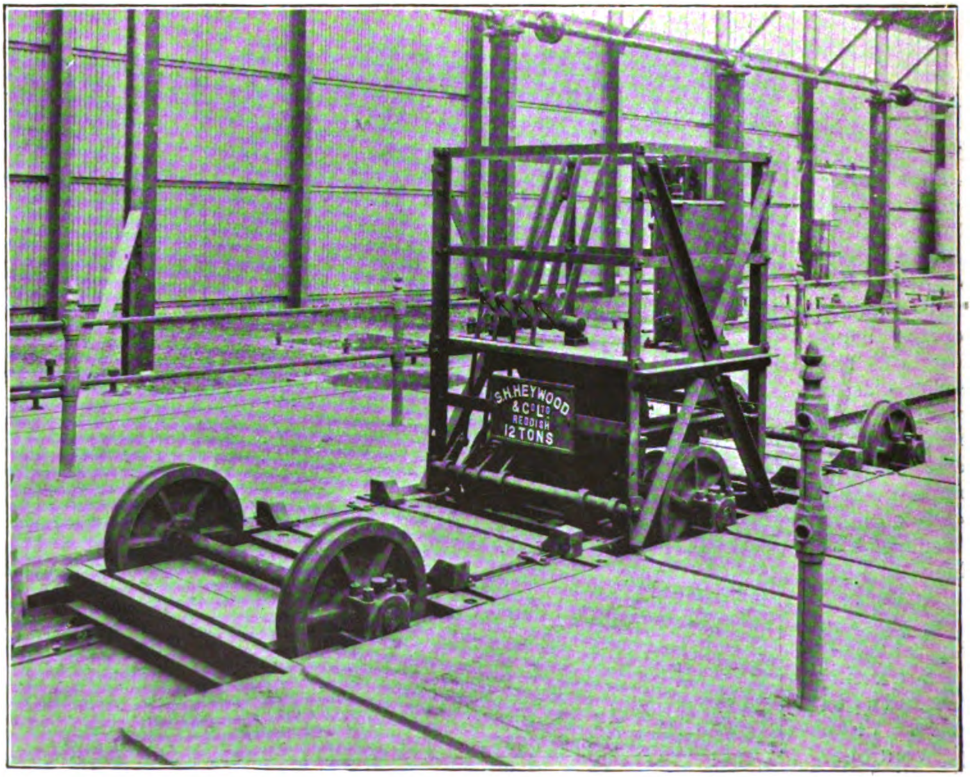


Fig. 1. Electrically Driven Traverser.

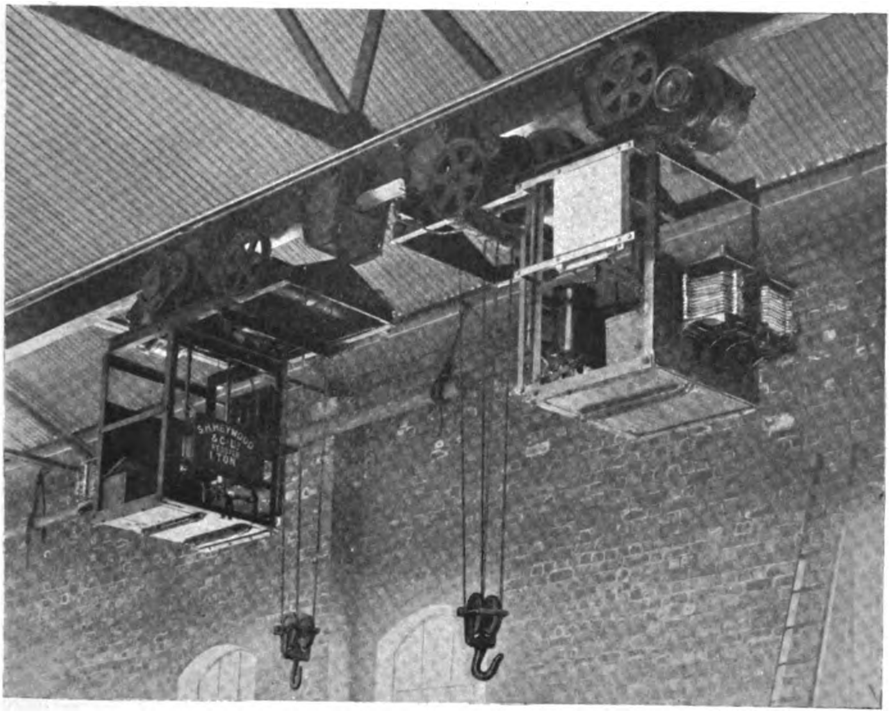


Fig. 2. Two One-ton Electric Transporters.

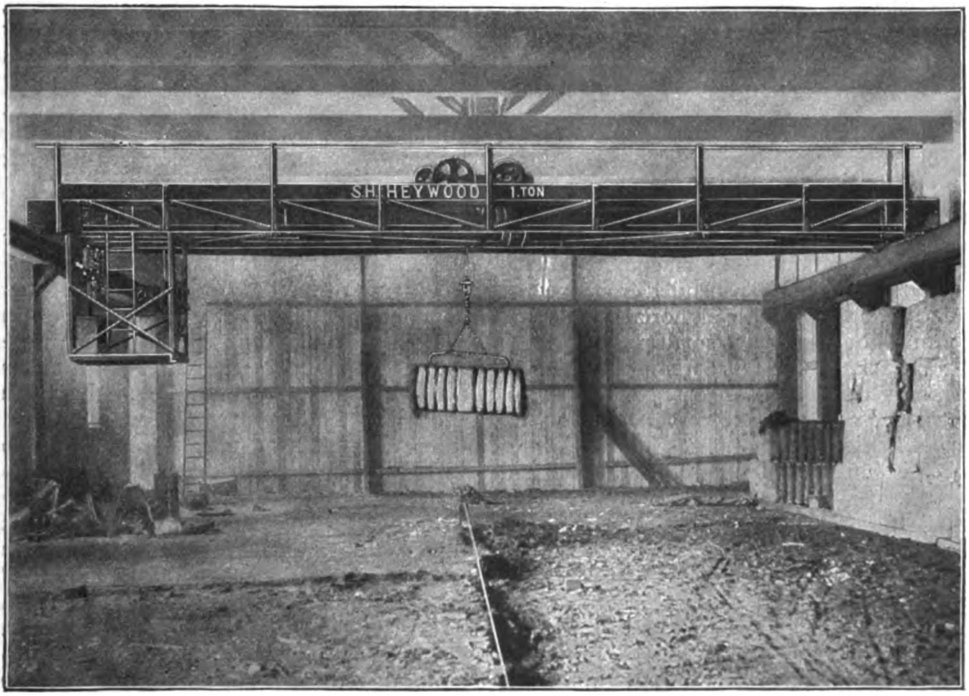
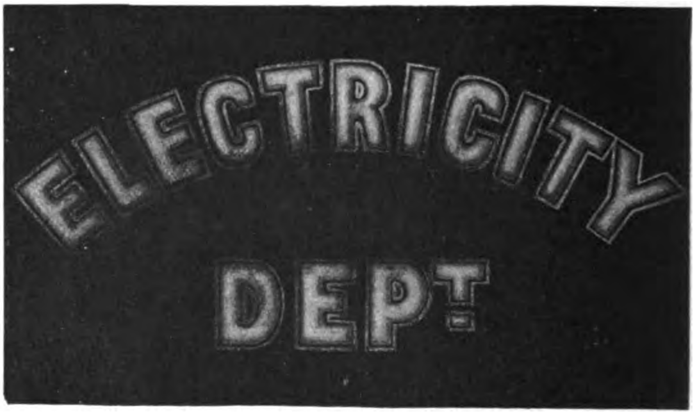


Fig. 3. Electric Travelling Crane.

levers on the operator's platform. The traverser is capable of carrying a load of 12 tons and travelling with same at the rate of 500ft. per minute. The conductors for transmitting the current are fixed in a recess on the inside of the track.

The third illustration, Fig. 3, is of a special type of overhead electric travelling crane, for use in storage warehouses in connection with textile mills. In addition to the main girders, auxiliary girders are provided alongside the same to ensure a rigid structure, and prevent cross winding in view of the high travelling speed. The operator's cage is placed at one end of the crane, and commands a full view of the whole of the warehouse. The motors are totally enclosed, and all the switch gear is enclosed in cast-iron cases to prevent risk of fire. The crane illustrated is of 33ft. span, and deals with a normal load of 1 ton at the following speeds: Hoisting, 30ft. per minute; cross traverse, 120ft. per minute; travelling, 450ft. per minute. A platform is provided along one side of the crane for inspection and oiling purposes, and is reached by means of a small ladder in the cage.

Illustration Fig. 2 shows two 1-ton transporters arranged to travel on the lower flange of a rolled steel joist, and provided with a cage for the operator to travel with the load. The whole of the hoisting machinery is fixed to a steel framework suspended from the two trollies arranged to swivel horizontally so as to run smoothly round small radius curves in the track. The centre framework of these trollies is constructed of cast steel; all gearing is machine-cut; and powerful brakes are provided for both motions. The size illustrated is capable of lifting 1 ton at a speed of 60ft. per minute, and of travelling at a speed of 500ft. per minute. The whole of the apparatus is of sound construction throughout, and has been proportioned and built for rough and continuous duty. An equipment of this description is especially suitable for transporting material from one shop to another, and loading and unloading ships, wagons, &c.



THE "LUXOL" ELECTRIC SIGN.

Electric Signs.

The Edison & Swan United Electric Light Company, Ltd., of 36-37, Queen Street, London, E.C., are placing on the market a new type of electric sign. The sign is made with fully rounded glass letters, mounted so as to be interchangeable if required, and presents a most attractive appearance, not only whilst illuminated, but also by daylight. These letters resemble snow in colour, and are made with bevelled edges. It is claimed that the sign is more economical in use than any other type of electric advertisement, as a single 5c.p. lamp is sufficient to illuminate the whole of an 8in. letter. The letters can be obtained in ranges of size suitable for all classes of premises, varying as they do from the small 4in. letter, by successive steps of 6, 8, 10, and 12in., up to the large 16in. letter, which presents a most bold and striking appearance.

When fixed, the lamp and holder are completely covered by the letter, so that there is no light and shadow effect, whilst the entire depth of the letter and sign box need not exceed 5in. The system lends itself well to theatre and similar purposes, where the announcements require to be varied from time to time, owing to the ease with which the letters are interchangeable. A further advantage possessed by the sign is that by reason of the rounded surface of the letters the sign can be seen and read with ease at an angle that would render the ordinary type of sign invisible. If required, the sign can be arranged to work with a motor-driven switch for blinking, changing colours, or switching on letters in rotation.

The sign is sold under the name of "Luxol," and the prices are extremely moderate, whilst the workmanship and general finish of the article leave nothing to be desired.

The lamps used with the signs, in order to obtain the greatest efficiency, are the well-known "Royal Ediswan," which need no further description.

Switches and Accessories.

ONE of the most extensive switch and electric detail manufacturing concerns of this country is that of Messrs. Wm. McGeoch and Co., Ltd., of Glasgow, Birmingham, and London. Their products cover practically every requirement in the shape of electrical detail apparatus for industrial and domestic usage. The standard form of quick-break knife switch is illustrated in Fig. 1. These switches are intended for either lighting or power circuit switchboards. The blades, contacts, and pins are made of high conductivity hard-drawn copper strip, mounted on enamelled slate. The fixing holes are bushed and the switches supplied complete with cable sockets, and arranged with either front or rear connections.

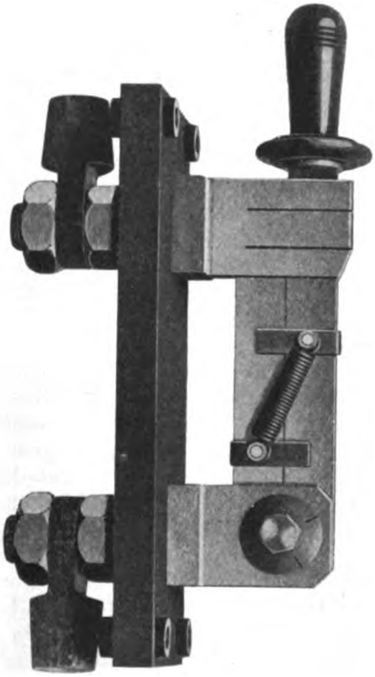


Fig. 1. Quick-break Knife Switch.

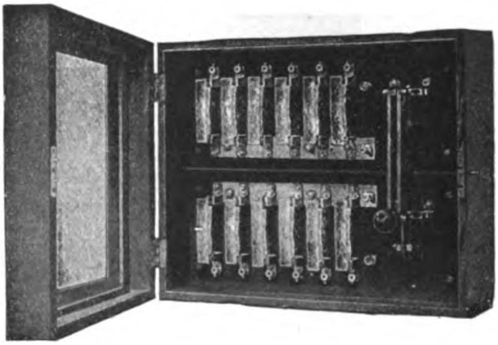


Fig. 2. Distribution Board.

When desired, the switches can be fitted with stops to prevent the switch arm from falling over. They are stocked in single, double, and triple pole form, either mounted or unmounted.

Particular attention has been given to the design of switch and fuse boards for colliery use, and the manufacture of switchgear totally enclosed in gas-tight iron cases forms a distinct speciality of the firm. The illustration, Fig. 2, is of a compact form of distribution board suitable for high-voltage wiring circuits. This board consists of spring clip fuses having 2½in. break and double pole switch, mounted on enamelled slate slabs, the panels of each pole being divided by a fillet. The screws securing the slate are well bushed with insulating material, and the board enclosed in a teak case, highly polished, fitted with glass front, and provided with a lock and key. These boards are supplied for any required capacity up to 100 amps. and 250 volts.

Incandescent Lamps.

THERE is very much that is interesting and valuable in the lamp specialities of the Bryant Trading Syndicate, Ltd., Highbury, London. The "Royal Glow" lamp is not only supplied in all the well-known forms of plain, frosted, with reflectors, &c., but it is to be had fitted with a simple switching device in the cap by which either of two filaments may be lighted at will. The illustration, Fig. 2, shows the application of this principle to a dormitory lamp. In this case there is a full-power

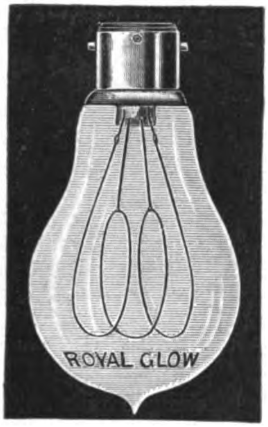


Fig. 1. The Bryant "Royal Glow" Lamp.

filament for ordinary use and a small candle-power filament which serves as a night light. The change-over is effected by tilting the lamp, which causes the bead of mercury to flow from one end of the little curved glass tube to the other, passing from the contacts of one filament to make contact for the other filament. This principle is also adapted for switching lamps on and off in dangerous explosive atmospheres; the tube, being hermetically sealed, forms an absolutely safe contact maker. The principle is particularly suitable for hand lamp work, the laying down of the lamp meaning the automatic switching off of the current. The company also manufacture a "Twist" lamp, in which the vitrite lamp cap is provided with addition contact plates whereby any one of the two or three filaments with which the lamp is fitted may be switched on at will by simply twisting the lamp in its socket. These lamps are all made in England of British materials, and it is to be recorded that the makers are favoured with a very large export trade.

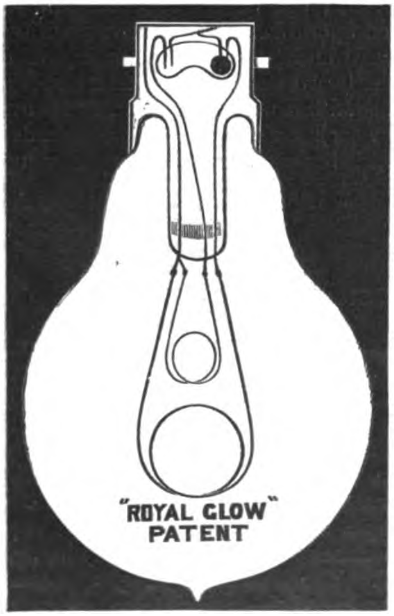


Fig. 2. Two-filament Dormitory Lamp.

Noiseless Gears.

One of the most important of the several businesses which practically owe their existence to the great development of electric power is the manufacture of flexible or non-metallic cut-gears. Raw hide, leather, paper, and other fibrous materials are all used for the formation of pinions, and each style has its own adherents or is particularly recommended for certain classes of service. Where spur gearing is used for an electric drive there can be no doubt that the raw-hide pinion provides a noiseless, durable, and easy running gear, suitable for the driving of any class of machinery. It is the best-known way of transmitting power from a motor to any kind of machine, and is far superior to cast-iron at high speeds.

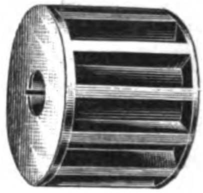


Fig. 1. Buffoline Pinion.

The armature of a motor fitted with this silent gear is not damaged by shock as when a metal gear is fitted; consequently the life of the motor is prolonged, and its efficiency unimpaired for a long time.

The Buffoline gears, illustrated in Figs. 1 and 2, are manufactured by the Buffoline Noiseless Gear Company at their works in Levenshulme, Manchester. These gears are composed of the finest buffalo raw hides, dried by a special process. The gears are made by building up the blanks from discs of this dried hide, about $\frac{1}{16}$in. thick, cemented together, pressed between metal plates and the whole riveted together. Large pinions, or pinions required for heavy driving, are fitted with a square metal bush to take up the strain of the drive.

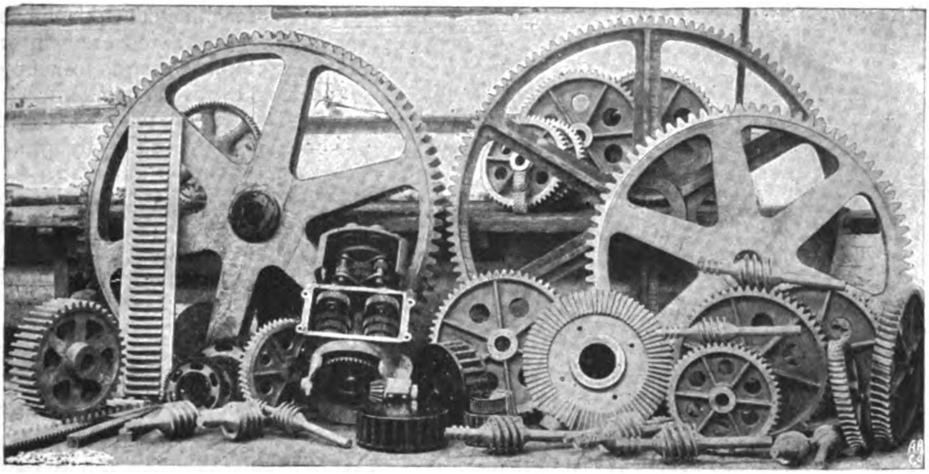


Fig. 2. Examples of Buffoline Pinions and Gears.

These gears have worked satisfactorily all over the world on pumping machinery, mining machinery, and for all other classes of plant. They are manufactured to transmit any power up to 200h.p.

The makers of the Buffoline raw-hide gears also manufacture every class of metal gears up to 12ft. diameter. They have recently put down an efficient plant for the accurate production of motor-car gears, and also make a speciality of worm reduction gears and gear-cases for reducing the speeds of motors.

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Milling Machines.

The illustrations on pages 90 and 91 are of machine tools made by Messrs. H. W. Ward & Co., of Birmingham, who are well-known as a leading firm in this class of business. Fig. 1 shows a plain milling machine such as is used for all general milling purposes. It is of very rigid design, the head-stock and bed being cast in one piece, the main casting having a substantial slide down the front face carrying the knee bracket. The spindle is of steel, hardened and ground, and runs in conical gun-metal bearings. It has suitable and efficient arrangements for thrust and wear, and is driven by a three-speed cone pulley, carrying a wide belt and double gearing: this, together with the two speeds on the countershaft, gives twelve changes of speed. For the convenience of fastening and removing the mandrils, there is a hole right through the spindle, and a bar is supplied for forcing out the mandrils. The steady bar is of steel, and is securely held by two bolts and split grips. It can be readily adjusted as to position, and carries on its outer end a steady bracket for supporting the end of the mandril. The bush for this purpose has a parallel hole which the end of the mandril runs in; this method allows the mandril to expand, under heat from cutting, without bending. This bush is split and tapered on the outside, so that it may be adjusted to take up wear by means of a pair of lock nuts. A steady brace is supplied, when ordered, to tie the cylindrical steady bar rigidly to the knee bracket of the machine, thus reducing vibration to a minimum. The knee bracket may be lowered or raised by screw and bevel wheels, and is provided with an arrangement for locking in any position. The weight of the bracket and slides are taken on a ball race which gives a very free vertical adjustment. It may be fitted with vertical automatic feed with adjustable stops when desired. The middle slide has a good bearing surface on the knee bracket, and a hand movement by handle and screw. Automatic feed and stops may also be fitted to this movement.

The table of the machine illustrated is 3ft. 7in. long by 10½in. wide over all. It has an oil or suds dish cast around it, and three tee slots are planed in its surface for the convenience of securing work, vices, or jigs. It has both automatic and hand feeds; the screw is of large diameter, and is driven by a pair of

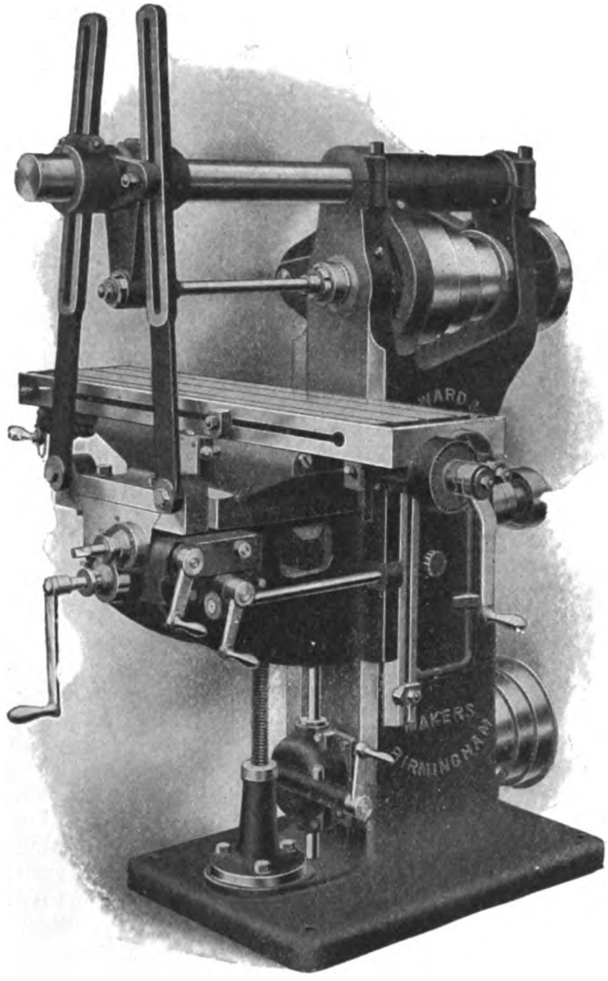

FIG. 1. PLAIN MILLING MACHINE.

small spur wheels from a separate shaft running underneath. The automatic feed is reversible by the lever on the small box at the foot of the machine, which operates a clutch between a set of reversing bevels. A quick-hand return motion is fitted, and automatic adjustable trips for the feed are arranged. The feeds are driven from the tail-end of the spindle by belts on interchangeable pulleys, which give in all twelve changes, ranging from .006in. to .24in. per revolution of spindle. The standard machine is fitted only with automatic feed to the longitudinal movement of the table; but automatic feeds to the cross and vertical feeds are supplied (as illustrated) when specially ordered. Adjustable automatic trips are fitted to all the feeds. All the gearing is machine-cut from the solid blank, and is covered in with neat cast-iron guards to keep out dirt and prevent accidents.

A vertical type of milling machine, size 24in. by 9in. by 15in., is shown in Fig. 2.

The table has both automatic and hand feeds. The hand wheel gives a quick return to the table, and the screw for moving the table is fixed and has no keyway along it; the nut is a long revolving one, thus securing the best possible condition for prolonging the wear and accuracy of the screw. The handle for operating the table is in a most convenient position at the right-hand side of the machine, and is indicated to read $\frac{1}{1000}$th of an inch. The power feed is provided with auto trips, with ample range of feeds for all purposes. The feeds are driven independently by a two-speed cone pulley from the countershaft, and arrangement is made on the countershaft to automatically throw off the feed belt at the same time as the belt for driving the machine, so that in the event of any accident occurring the whole machine is at once stopped by moving the lever. The change feed box is at the foot of the machine, and contains a reversing motion, applicable to all the feeds, and eight changes of feed operated in all by three levers, one for the reversing and one for giving an immediate change from a roughing to a finishing feed. The box carrying this change gear is arranged to carry a large supply of oil in which the gears, which are of steel, are constantly running, thus ensuring perfect lubrication of all parts. By drawing one shaft, and taking out four screws, the box containing the whole of the gears may be removed intact for inspection. All the trip motions are obtained by drop-out worms, which is the quickest and surest method of stopping the feed motions.

The circular table, $13\frac{1}{2}$in. diameter, is fastened to the table by four bolts, and the base of it is slotted out where the bolts come, to facilitate its removal. It may be

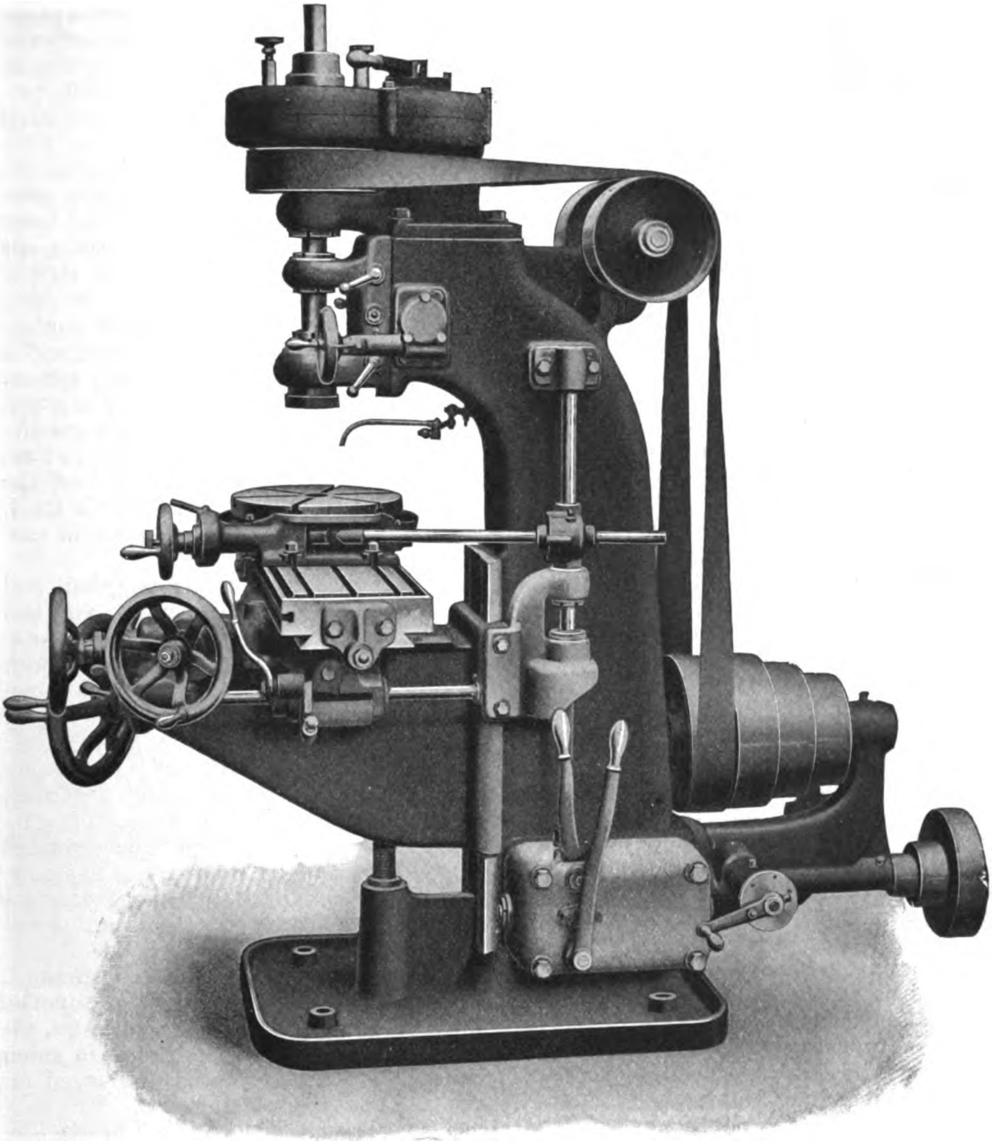

Fig. 2. Vertical Type Milling Machine.

revolved by worm and wheel, either by hand or automatically, sixteen different rates of speeds being obtainable. A friction clutch operated by the knurled knob in the centre of the hand wheel enables the automatic feed to be started or stopped immediately. The hand wheel is indicated to read in degrees.

The body of the machine is a strong box casting, and the base of it is arranged in the form of a tray to catch any superfluous oil or suds, thereby keeping the shop floor in a cleanly condition. All the gearing on the machine is machine-cut from the solid blank, and is efficiently and neatly covered in to prevent accidents and keep out dirt. The bearings and loose running shaft are, where necessary, bushed with hard gun-metal. The countershaft is supplied with two sets of fast and loose pulleys, and an independent drive for the feed motions and pump, and arrangement is made for stopping both the main and feed belt by the movement of one lever. The machine is supplied complete with countershaft, circular table with automatic feed, automatic feed in two directions to the table, one mandril, and necessary case-hardened spanners.

Messrs. Ward are also makers of a large variety of other classes of machine tools. Of these mention should be made of a line of high-speed combination turret lathes fitted either with all-gear or cone-driven headstocks, and designed throughout for the full use of modern high-speed steels. It is of interest also to note that this firm has given special attention to the building of grinding machines, the increasing use of which has of late years been very much to the fore.

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Boring and Turning Mills.

Boring and turning mills have been made by Messrs. Geo. Richards & Co., Ltd., Broadheath, Manchester, for many years; they have given particular attention to the perfecting of these machines, which form one of their leading, if not the chief, of their specialities. In them the most modern improvements have been introduced, and the machines have been designed with special regard to the requirements at the present time for heavy cutting with coarse feeds, using high speed steel, combined with convenience in operating the motions.

There is no doubt that boring mills for all classes of chuck work are fast taking the place of ordinary face-plate lathes. The advantages of the former over the latter are many and important, and it has been proved that not only can work be more readily set on a boring mill, but the operation is usually performed in a much shorter time and in a more satisfactory manner. One great point in their favour is that irregularly shaped work does not require accurate balancing before being run at high speeds, as is the case with face-plate lathes.

In these tools the large annular bearing under the table is of a special form, and rotates in a reservoir of oil. This form of bearing gives special rigidity to the table, and permits of the same being rotated without undue friction at suitable speeds for boring. At the side of the machine a gauge is fixed to indicate when there is sufficient oil in the reservoir. The table is driven by spur gearing on its periphery, which prevents any tendency to raise the table when taking heavy cuts.

The cross slide has long bearings on the uprights, and the square slides which carry the tool bars are guided only by the lower member of the cross rail, which ensures, not only increased accuracy but greater rigidity to the tool bars. Each machine is fitted with their new patent positive feed motion, which is a very compact arrangement, and is a great advance on the sliding key system. The whole of the gears are encased in a box, which is dust-proof, and contains a quantity of oil, into which the gears dip and are thereby lubricated. At each end of the cross slide a friction slipping device is fitted, to prevent breakage to feed gears in case the heads accidentally collide.

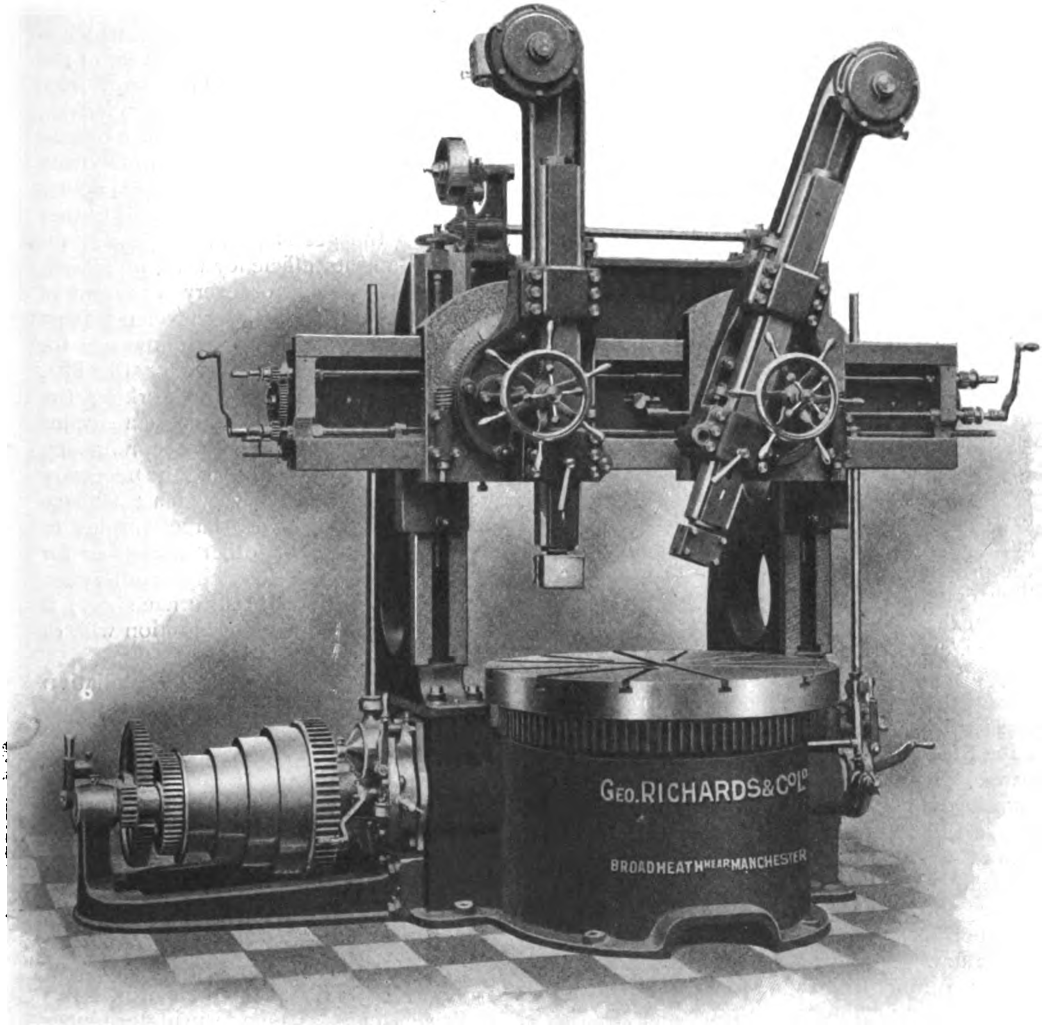
Twelve rates of feed are provided, and these can be changed instantly. The tool bars are balanced by a patent spring balance arrangement which entirely does away with the use of weights and chains, and does not in any way impede the operator in the manipulation of the machine, which is the objection to the ordinary method of balancing. Further, the bars are more easily operated by hand, and pieces of work can be placed directly over the centre of the table by a crane, which is not so readily done in those mills whose tool bars are balanced by chain, and the chain passes over the table.

In the ordinary way the mills are arranged with cone drive, but they are also supplied fitted with a variable-speed gear device, the number of speeds being the same in either case. The machines are also arranged for direct motor drive when needed.

They are rigid in design, and in this connection it is important to notice that the makers guarantee the actual limits of error.

A complete range of these mills from 3ft. up to 10ft., twelve sizes in all, is standardized. The illustration shows the 4ft. size, the guarantees as to error limits in this case being—

Size of mill, 4ft.
Down feed, 20in.
Boring a hole or turning a piece full depth of down feed, holes or dia. parallel to, 0.00125in.



Boring and Turning Mill.

The ram square with table to 0.000625in.
The table flat to 0.0015in.
Spindle round to 0.00025in.
Test piece turned or bored on machine round to 0.0005in.

Large Gas Engines.

THERE is probably no subject in which power engineers are more widely interested at the present time than the development of high-power gas engines. For some few years past remarkable progress has been made in the perfecting of the eight or ten standard designs which have been adopted by leading British, Continental, and American engine builders. The principle of the gas engine is old, and its commercial success in small sizes is universally accepted; it would seem that the troubles of the very large sizes have been largely due to mechanical shortcomings. Practice only is required to establish the large gas engine as a permanently satisfactory power generator. As to the economy of utilizing gas direct in the engine cylinders, whether the gas be intentionally generated for the purpose in producers, or whether it be as the bye-product of coke ovens or blast furnace, there are no two opinions; and given the perfected mechanical design the gas engine will certainly be accepted as the leading prime mover.

One of the first large gas-engine installations set to work in this country was the plant of the Cargo Fleet Iron Company, of Middlesbrough, which was installed some four years ago and consists of seven 800h.p. single-acting gas blowing engines. A general view of the power-house interior is shown on page 95. The engines are of the well-known Cockerill type, built by Messrs. Richardsons, Westgarth & Co., Ltd., Middlesbrough, the sole licensees for Great Britain.

This engine works upon the ordinary Otto cycle, and is fitted with two electric ignitions to ensure certain and rapid combustion of the gas. The design is exceptionally heavy, and the principal strains are all in a direct line. The cylinders, pistons, piston rods, covers, and exhaust valves are carefully water cooled, and the engine is controlled by an improved centrifugal governor which varies the quantity of gas admitted according to the load. A constant compression is maintained to balance the weight of reciprocating parts, thus insuring exceptionally steady running. The gas and air inlets are placed above the cylinders, and the exhaust valves below, each set being driven by a single cam and roller on the side shaft. This makes the engine most accessible, and the number of working parts is reduced to a minimum. For large powers, and where steady running is required, two or more double acting cylinders are fitted.

This type of gas engine has been working longer than any other large-size gas engine on the market. Two 250h.p. engines, driving dynamos, have been running continually with blast furnace gas since April, 1898, and two 800h.p. blowing engines since November, 1899. One 800h.p. blowing engine has been working for seven years at Messrs. Cochrane & Co.'s Ormesby Iron Works, Middlesbrough, using Cleveland blast furnace gas with most satisfactory results.

From the results of very carefully made experiments conducted by Professor Witz, in July, 1898, and Professor Hubert, in April, 1900, it has been found that these engines of large size do not use more than about 100 cubic feet of average blast furnace gas per effective horse-power per hour, which is less than one-fourth the consumption of gas required to develop the same power from boilers and good modern condensing steam engines, so that there is an immense surplus of power to be obtained from a blast furnace if the blowing engines are worked by gas, which can be still further increased if the gas is properly cleaned for the stoves, and its efficiency thus increased. It is estimated that for every 100 tons of coke used in an ordinary Cleveland blast furnace, after making ample allowance for gas for the stoves and power for the lifts, pumps, &c., and for gas for working the necessary blowing engines, there is a surplus of at least 1500h.p., so that by economizing gas by cleaning and developing the necessary power by gas engines, every blast furnace owner would have a very large surplus of power for his steel or other works, or for selling in the form of electricity or otherwise. These figures refer to blast furnace gas; if better gas be used the consumption will, of course, be proportionally less.

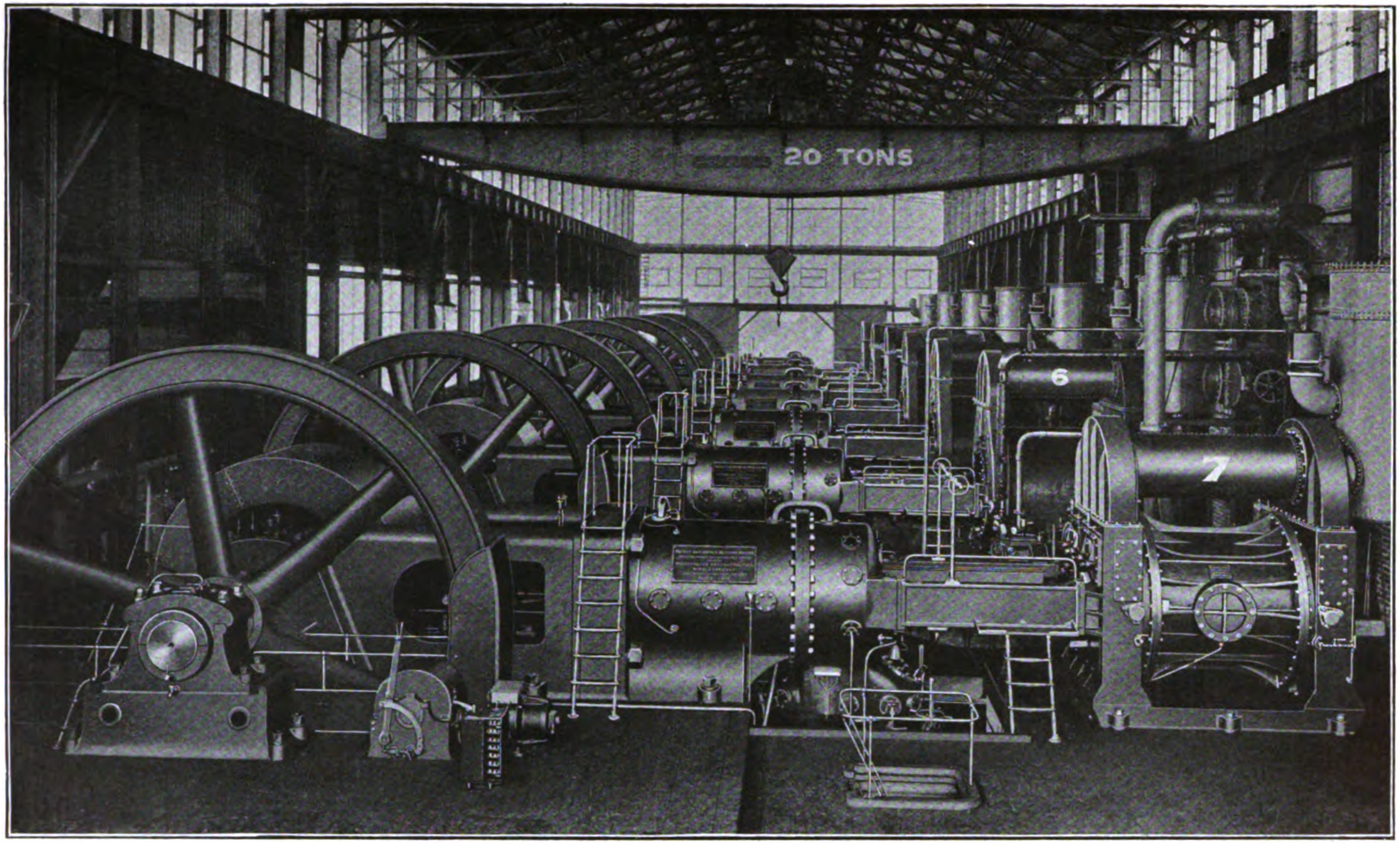
Since supplying the Cargo Fleet installation Richardsons, Westgarth & Co., have considerably improved the gas engine, all cylinders now being made double-acting, and the details of the valve gear, &c., have also been greatly improved. Up to the present this firm have already supplied or have in process of manufacture over 28,000i.h.p. of large gas engines, including engines of 1700i.h.p. for driving both continuous current generators and alternators and to use blast furnace, producer and coke-oven gas. For about a year part of their works has been driven by a gas engine using producer gas.

"Everything Electrical."

THE General Electric Company, Ltd., of London, belong no doubt to the most enterprising and successful of English manufacturers of electrical goods.

At their large works at Witton, Manchester, Birmingham, and London, they manufacture everything, from the terminal screw upwards to the largest generator and motor.

From their well-equipped works at Witton the G.E.C. have turned out some excellent machinery, such as 500k.w. motor generator sets for the London County Council sub stations — about twenty in number—and



INTERIOR VIEW OF GAS ENGINE HOUSE OF THE CARGO FLEET IRON COMPANY, LTD., MIDDLESBROUGH. THE PLANT CONSISTS OF SEVEN 800H.P. GAS BLOWING ENGINES.

340 motors, each of 40h.p. capacity, for working the lifts of the London underground electric railways.

The "Witton" Carbon Works, the only carbon works in England, supply carbons to the British Admiralty and War Office.

"Geekoduct," the G.E.C.'s steel conduit, is also manufactured at Witton.

Amongst other leading lines should be mentioned telephones and telephone exchange boards, for the manufacture of which their "Peel" Works, Manchester, are excellently adapted. At the "Peel" Works are also made electric light accessories, ammeters, and voltmeters, the "Archer" system of heating and cooking apparatus, and the "Angold" and "Flamgold" arc lamps.

The G.E.C. have done much for the progress of electricity in England. When incandescent lamp patents ran out, they were the first to start a lamp factory—the "Robertson" lamp works at Hammersmith, London, W., where about 5,000,000 lamps are made annually. They erected the first three-phase plant in England, and own the only carbon works in the United Kingdom.

One cannot wonder that they pioneered the metallic filament in this country; and they are now erecting the first large works in England to manufacture the "Osram" or "Wolfram" (Tungsten) metallic filament lamps, the patent rights of which they have acquired. With large and important branches in the principal Colonies the G.E.C. upholds the name for thoroughness which British-made articles enjoy, and this applies to all articles coming under their comprehensive slogan "Everything Electrical."

BOOKS RECEIVED.

Pressure of space compels us to hold over reviews of several important books and publications. Amongst those received are the following :—

Who's Who, 1908. (LONDON : A. & C. BLACK, SOHO SQUARE, W. PRICE 10s.)

Who's Who Year-Book, 1908. (LONDON : A. & C. BLACK, SOHO SQUARE, W. PRICE 1s. NET.)

Hazell's Annual, 1908. EDITED BY WILLIAM PALMER, B.A. (LOND.) (LONDON : HAZELL, WATSON & VINEY, LTD., 52, LONG ACRE, W.C. PRICE 3s. 6d. NET.)

Daily Mail Year-Book, 1908. EDITED BY PERCY L. PARKER. (LONDON : THE ASSOCIATED NEWSPAPERS, LTD. PRICE 6d. NET.)

Cassier's Magazine. GAS POWER NUMBER. (LONDON : THE LOUIS CASSIER COMPANY, LTD., 33, BEDFORD STREET, STRAND, W.C. PRICE 2s. 6d.)

Practical Coal-Mining. VOLS. 3 AND 4. EDITED BY W. S. BOULTON, B.SC., F.G.S. (LONDON : THE GRESHAM PUBLISHING COMPANY, 34, SOUTHAMPTON STREET, STRAND, W.C.)

Modern Views of Electricity. BY SIR OLIVER LODGE, D.SC., LL.D., F.R.S. THIRD EDITION REVISED. (LONDON : MACMILLAN & CO., LTD., ST. MARTIN'S STREET, W.C. PRICE 6s.)

New Catalogues, &c.

With the turn of the year we have received very many of the usual seasonable gifts from our manufacturing friends. Amongst the more noteworthy of these should be mentioned the following :—

Callender's Cable and Construction Company, Ltd., have sent us a well-produced card for cable calculations. This will be found of everyday service to the wiring contractor and indeed to very many electrical engineers. The section of conductors for various circuits and services are readily obtained by its use.

United States Metallic Packing Company, Ltd.—For years past this firm has been in the habit of sending out very distinctive wall calendars. Their latest well maintains the standard of artistic merit and usefulness.

T. W. Broadbent, Ltd.—The wall calendar sent by this firm is an artistic production carrying a coloured reproduction, "Harvesting in Hertfordshire." Messrs. Broadbent make a point of mentioning that whilst their supply of these is limited, they will be pleased to distribute them free to interested parties on application.

Marples, Leach & Co.—The season's gift of this firm takes the form of a small slide rule. This is certainly an original idea, and, of course, its utility is obvious. We have since received a letter from the firm indicating that the demand for the rules has been so great that they are out of stock, but that a further supply will be procured. Those of our readers, therefore, who should request one of these rules will understand the reason for delay in its supply.

Johnson & Phillips, Ltd.—A neat little waistcoat pocket diary is the form of this Company's gift. Copies of it will be sent to any electrical firms on application.

Mountain & Gibson, Ltd.—A very useful leather-bound pocket diary has been sent us by this firm. This, of course, carries the usual insurance coupon and has the particular merit of being of handy size and yet affording full space for daily notes.

British Electric Transformer Company, Ltd.—Probably no other present is more useful than the Whitaker's Almanac which this Company has for some years past made a practice of presenting. Everybody knows Whitaker, and we need only say that the volume presented is of the high-grade padded morocco, gilt-edged edition.

Geipel & Lange.—This firm has distributed a convenient style of leather-bound pocket diary, which will be found of much use by engineers.

Electrical Power Storage Company, Ltd.—This Company has established a definite line of calendar, diary and blotting pad combined. The new issue is well up to previous standards and will be found on the majority of electrical engineers' desks during the year.

B. Gibbons, Jnr., Ltd.—Gibbons Bros., Ltd.—These firms, well-known makers of fire-brick specialities and as engineers and contractors respectively, send us a desk blotter and memorandum pad which is of an exceptionally useful form.

Flame Arc Lamps.—CROMPTON & CO., LTD., LONDON, E.C. An illustrated pamphlet describing the Crompton-Blondel system of flame arc lighting.

Electrical Novelties.—F. DARTON & CO., CLERKENWELL, LONDON, E.C. Under this title Messrs. Darton have issued a new edition of their comprehensive catalogue dealing with a full range of small electrical apparatus, including motors, fans, telephones, bells, and general experimental material.

Friction Clutches, Haulages and Rubber-Preparing Machinery.

The Heywood & Bridge friction clutch as made by Messrs. David Bridge & Co., Castleton Ironworks, Castleton, Manchester, has come into very general use for a wide variety of purposes. A full description of this clutch appeared in The Electrical Magazine of July last. It is built in all sizes and has been supplied for various transmissions of powers from ½h.p. up to 2000h.p. The illustration Fig. 1 shows its application to a 400b.h.p. Diesel oil engine drive, which is an example of many similar gas and oil engine main drives which have been fitted by Messrs. Bridge & Co.

In hauling installations the attendant is continually rung up to stop and start the haulages according to conditions; therefore it is often better to use a friction clutch than to keep continually stopping and starting the motors. Some very heavy haulage installations of this type using the Heywood and Bridge clutch are now successfully at work, some of which are transmitting over 1000h.p., and hauling thousands of tons of coal per day. Messrs. David Bridge & Co. have had an exceptional experience in haulages for collieries, quarries, gold mines, brickfields, &c.

The firm are also makers of every description of mill-gearing and have carried out the entire millwrights' work of many of the largest textile mills in this country. In mining work, also, they have established a reputation as builders of various machines, and have many important plants of this description at work in this country and abroad.

Hydraulic plant in the form of a wide range of pumps, presses, and accumulators also forms an extensive branch of Messrs. Bridge & Co.'s work. They are also the licensees and makers of the Baker patent oil separator and vacuum pumps for the extraction of oil and grease from exhaust steam; and they make a further speciality of steam dryers and separators.

The illustrations on the following page, Figs. 2 and 3, show installations of rubber-preparing machinery put down by Messrs. Bridge & Co. Fig. 2 shows a three-bowl calender machine driven through a chain of helical gears by an electric motor, as recently supplied to a large rubber factory. A group of three rubber mixing machines, also electrically driven, is shown in Fig. 3. For the manufacture of rubber and rubber goods, the Company supplies every class of machine and apparatus necessary in all the processes, from the tapping of the rubber trees to the finished commercial article in the form of rubber-sheeting, waterproofs, tyres, &c. These machines include washing machines for the first treatment of the imported crude india-rubber, by which all foreign matter is washed and pressed out of the material; mixing machines for working the compounds necessary into the pure washed rubber; grinding machinery for tearing-up and grinding old scrap-rubber for reclaiming purposes; dough mills for preparing the rubber for calendering; calenders, plain and embossing, for rolling rubber sheets, moulding shoe soles, &c.; spreading, chalking, and measuring machines for the manufacture of waterproof fabrics. In addition to these machines various styles of vulcanising plants, presses and moulds—the presses being adapted for hand, belt, or hydraulic power—are made. They also build machinery for the preparation and working of gutta-percha and balata. Many of the most important rubber factories in this country and abroad have been supplied with Messrs. Bridge and Co.'s machinery. Recent orders for machinery include various plant for Canada, Africa, and the Continent.

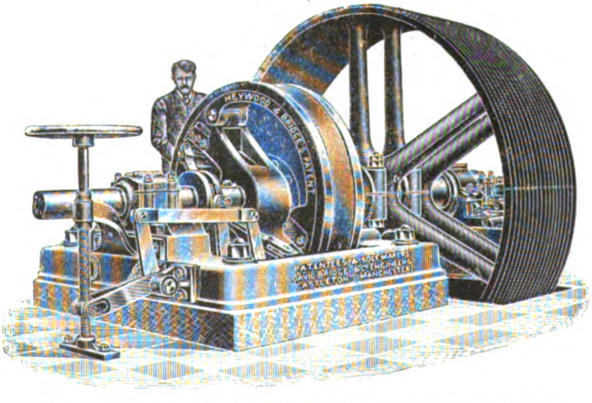


Fig. 1. 400b.h.p. Diesel Oil Engine Drive, fitted with Heywood and Bridge Friction Clutch.

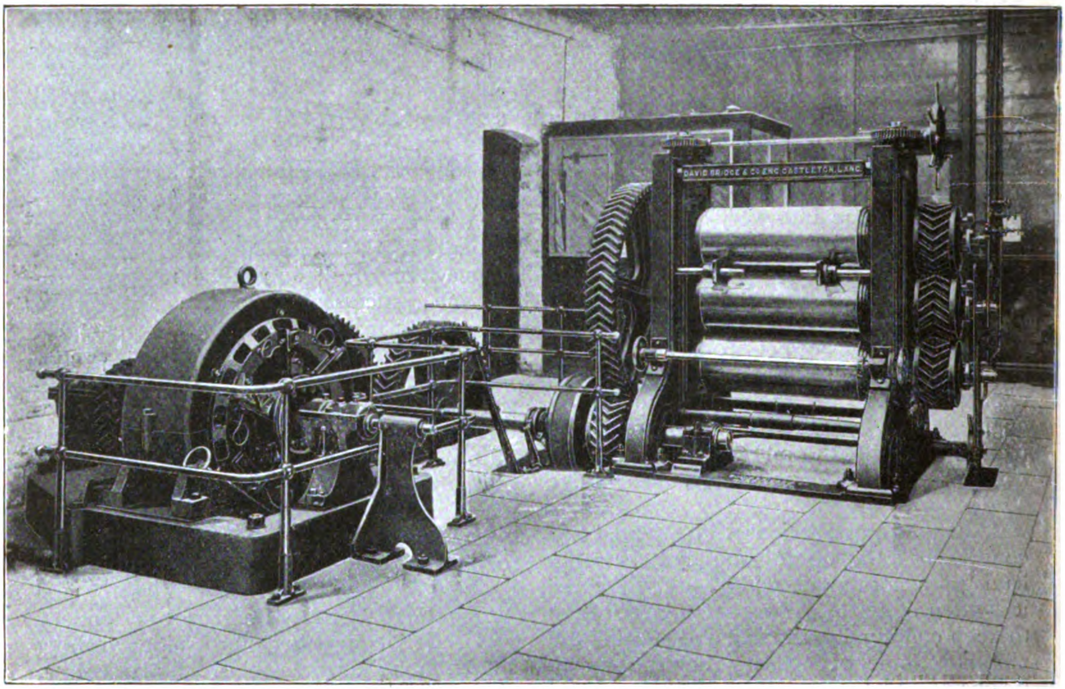


Fig. 2. Rubber Calendering Machine, Electrically Driven. David Bridge & Co., Castleton, Manchester.

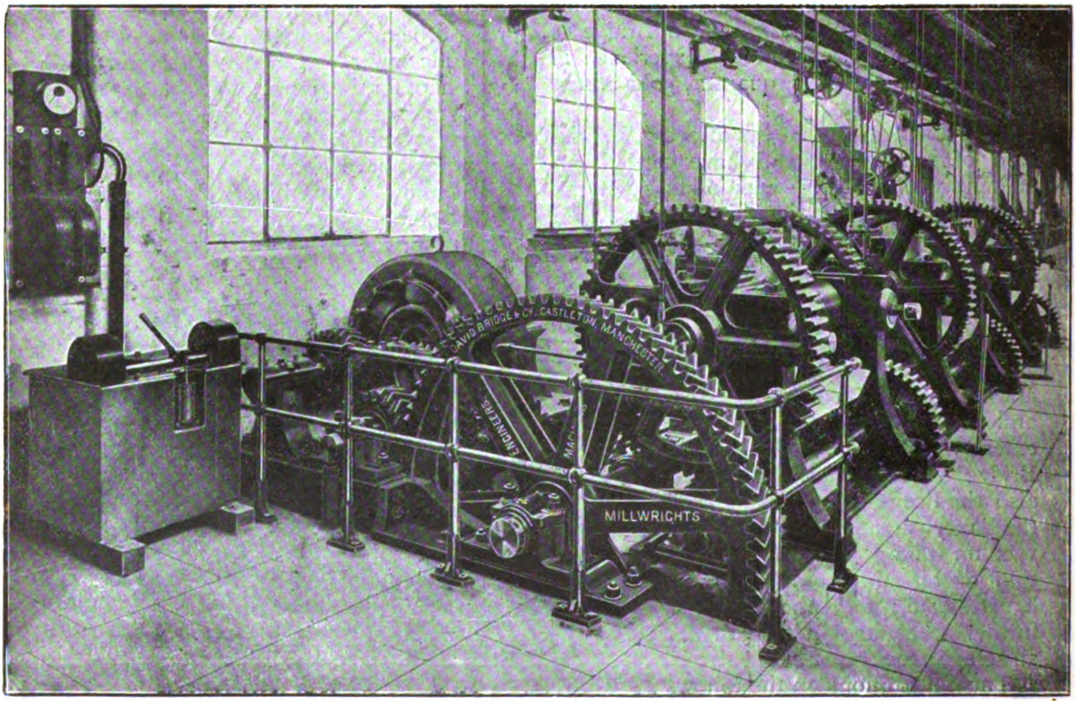


Fig. 3. Rubber Mixing Machines Electrically Driven. David Bridge & Co., Castleton, Manchester.

(49th Issue.)

The Electrical Magazine.

FOUNDED AND EDITED BY
THEO. FEILDEN.

VOL. IX. NO. 2. LONDON. FEBRUARY 15th, 1908.

The World's Electric Progress.

Electricity in the Iron and Steel Industries.

READERS will be interested to know that we have in preparation, for publication during April, a great Iron and Steel Number of THE ELECTRICAL MAGAZINE. The wide popularity accorded to our Colliery and Textile Numbers, which appeared respectively in March and July of last year, indicates that the "Industrial Series" of this journal is proving of benefit to a very large circle of engineers. The third of the series will be devoted specifically to the uses of electricity in the iron and steel industries. There can be no two opinions as to the value which such a publication will have. For years past the power equipment of iron and steel works has been one of the most important branches of the electrical power contractor's business, and to-day it has assumed immense proportions both in sizes of units required and in the special designs and arrangements necessary for the many heavier grades of work which are rapidly being taken hold of by the electric motor. There are problems connected with the application of the electric drive in these industries which do not occur in any other manufacturing sphere. The duties of the motors are at all times arduous, they having to handle loads which are mostly intermittent, and of the heaviest powers; as a rule the surrounding conditions of temperature and exposure are of the most adverse description; frequently the power end is in the hands of rough, unskilled labour; in short, the demands of load and the working conditions are unique, and consequently the perfection of electrical power engineering is exhibited in such work so far as the plant employed is concerned, and the most careful design and expert services are necessary in the lay-out of the installations.

The power requirements of the blast furnace are extremely varied, the accessory plant in particular entailing many special forms of driving. Coal-crushing, washing, and elevating; furnace-chargers and rams; pug mills, elevators, and briquetting plants; pig-breaking, handling, and loading—all these and many more plants, complete in themselves, are generally electrically driven. The handling of raw materials and finished product is, in itself, one of the most important phases of the power installation in iron and steel works. Even the handling of slag at the furnaces and at the slag works, where it is worked up for commercial purposes, is frequently the duty of electric motors. Similarly in steel works, in rolling mills producing rails and plates of heavy section, the use of electric power is general, and the duties equally, if not more, arduous and exacting.

No iron and steel works power scheme can be approached nowadays without the first consideration of the power-generating possibilities of the available spare blast-furnace or coke-oven gases. It is now conceded that these gases can be best utilized direct in gas-engines, as against their combustion under steam-boilers, and that the gas-electric power generating plant affords the most efficient, convenient, and reliable means of economically conserving this valuable asset.

Then again there is the recent revolutionary development of steel furnaces in which electricity is the direct heating agent. The induction-type of electric steel furnace has quite advanced beyond the laboratory stage and is become a commercial plant. It is already in use on a commercial scale supplying product to market, and this practice has led to remarkable progress in its development; it would seem that for the production of special and fine steels the electric furnace has become firmly established. There is, of course, very much still to be done in this direction; the induction furnace utilizes simply the heating effect of a secondary current. Elsewhere in this number we publish an illustrated description of a new type of steel furnace which supplements the heating of the induced current with a direct application of the primary current, by electrodes, to the molten contents. It would seem therefore that induction, resistance, and even electrolytic types of electric furnaces will all have to be reckoned with in future by the steel manufacturer.

Thus we have three great subdivisions of the work done by electricity in the iron and steel industries: the application of electric motive power; the generation of electricity from by-product gas; and the electro-metallurgical processes. There are ot course all other general works uses requiring the current, but the three sections mentioned are all confined to these great industries alone or introduce in this connection such departures from standard every-day practice as to call for specific experience and treatment.

It is our intention to collect as far and completely as possible into one number of THE ELECTRICAL MAGAZINE all that is best and most up to date in reference to the problems underlying and the work done in the electric power generation, application and equipment of iron and steel works; also the most valuable and reliable information as to the use of electricity as the active furnace heating or chemical agent for the production of iron and steel both from ores and from the cruder forms of furnace product. This is no light task, but readers can depend upon the subject matter of the specially enlarged number being selected with discrimination. Experts engaged in actual practice are supplying us with exclusive and original articles on each and every one of those numerous phases where electricity enters into the commercial manufacture of iron and steel and the working of these commodities in bulk, such as occurs in rolling mills, shipyards, and similar heavy constructional works. The fact that the writers who are contributing are practical leaders in their respective spheres of work is in itself a guarantee of the accuracy and great value of the contents.

We feel sure that readers will appreciate our effort and intention, and would ask those who are interested to a practical extent in the application of electricity to the making, handling, and working of iron and steel, and who have information or ideas as to any process or work done in this direction, to forward us particulars for publication.

* * *

The Artizan's Tuition.

WHAT a vexatious question is that which covers the "Education of the Worker." Towards the close of last year a paper presented by Mr. W. G. Spence to the North-East Coast Institution of Engineers and Shipbuilders reported on the results of a scheme instituted some four years ago for the upraising of the engineer trade apprentice to a higher level of learning than his rule-of-thumb predecessor. An essential feature of the report is the half-expressed disappointment of another failure to induce apprentices to study well:

The impression the writer gathers is

> that the number of apprentices who do efficient evening-class work forms a very small percentage of the whole, and that, except in a few exceptional cases, the work is of quite a rudimentary character. It will be noted that little more than one out of every five apprentices show any results at all. One has heard much of late years as to the dangers attached to over-attention to book work. The results indicated should permit those who fear we are going to perdition from this cause to slumber in peace.

Surely it is about time that one should cease to expect the impossible in this matter. Why try to make "a silk purse from a sow's ear"? Perhaps it is rather harsh to make such a comparison, but there are at least as many sows' ears nowadays as ever there were, even though they may be glazed superficially as a result of national free and compulsory "education." This opinion seems to have been formed also by Mr. Spence, who, later in his paper, says:

> That the attention of those responsible for the allocation of educational grants should be specially directed to seeing that such grants are so arranged that the small percentage of specially able and hard-working youths are granted facilities for passing on to the higher technical schools and colleges, and that the chief business of evening classes should not be the production of a light crop over a large area, but rather the giving of assistance enabling a few to raise themselves above the average and pass on to further advancement.

There is another point in this report which merits notice in passing. The author states that at the particular works dealt with it is intended that the apprentice who heads the list each year

> shall, between the 1st October and 31st May next succeeding winter, commence work at 9 a.m. instead of 6 a.m., full-time pay being credited over this period. Should the same youth or youths be leading for a second or a third year in succession they will retain their privilege and, in addition, the next in order will obtain it. In other words, the head apprentice of those required to attend at 6 a.m. will always be selected in each year.

It is not at all certain that this move is a good one. The apprentice has gained his leading position by hard, painstaking work, and as such he will value the result as being something striven for. The very spirit in which he has tackled his work under arduous circumstances has probably more to do with his present and his ultimate success than any brilliancy of intellect. Remove the difficulties from his path and his is the loss. Say what one will, free education has not been an unmixed blessing to this country. Worse than ever is the tendency of the times—the worker is educated, given libraries, baths, meals for his children, and sundry other more or less essentials of life—*free*. At the same time he is ever agitating for more of these *free* gifts and—more wages. It would seem that there is the chance of the employer asking him why he wants any money at all when everything necessary is provided. The spur of ambition is no longer felt in any fulness; the masses are levelled by education and other "free" gifts. Man only really values that for which he has fought strenuously, and loses character and value when the fight is denied him.

Whilst on this subject of the worker's education we feel that there is another phase which needs looking into. We get many letters from readers who have taken up "Lessons by Correspondence." As a rule these are unhappy reading, and not a few have been positively pitiable. There are men who, led away by high-falutin' advertisements, have enquired of the "School" and been assured that after a course of lessons costing so much they would be certain of posts in a "Power Station" at a starting salary of £75 a year and so on. These men try to get appointments as engineers and write us to help them in this and to ask us also, in a forlorn sort of manner, whether they can really expect the promised appointments and whether they ought to have believed the director of the "School."

THE NEW PATENTS ACT.

By a Barrister.

AMIDST the clash of more contentious measures the Patents and Designs Act, 1907, came into operation on January 1st, 1908, practically unnoticed save by those few whose professional life is cast among inventors and inventions. The bold statesmanship of Mr. Lloyd-George, whose energy and business capacity are as freely admitted by his enemies as they are extolled by his friends, touches few subjects without revolutionary change. It is too early yet to predict with any certainty the precise effect of this measure, but it may well be that some short account of the more outstanding features of novelty in the latest Patents Act will not be without interest to the readers of THE ELECTRICAL MAGAZINE.

The advocates of fiscal reform have detected with triumph a strong flavour of protection in this prominent innovation. The speech in which the President of the Board of Trade introduced his bill to the House of Commons was certainly open to the construction which was immediately put upon it by the Unionist speakers, inasmuch as the so-called "compulsory working" clause was frankly admitted to be designed for the protection of British manufacturers from the crushing effect of a conspiracy of an inelastic enactment and a ring of wealthy German corporations.

The clause (27) as it finally emerged from Committee runs as follows:—

> "At any time not less than four years after the date of a patent and not less than one year after the passing of this Act, any person may apply to the Comptroller for the revocation of the patent on ground that the patented article or process is manufactured or carried on exclusively or mainly outside the United Kingdom."

There follow certain provisions as to machinery which need not be quoted here.

Now this provision is a complete novelty in this country, though for many years it has formed an integral part of the Patent Law of our most notable foreign trade rivals. In Germany, France, and Austria the same enactment is in force, subject of course to small variations of period and procedure. To take one example, the Austrian clause is as follows:—

> "A patent may be wholly or partially withdrawn if the patentee . . . . neglects to work, or allows to be worked, the invention in the country to a suitable extent, or to do everything necessary to ensure such working. The withdrawal may . . . . take place . . . . not earlier than after the expiration of three years from the date of the publication of grant of the patent in the patent journal."

The complaint which has given rise to the placing upon our statute book of this foreign growth is in the view of the writer a very genuine grievance.

Without entering into the vexed question of the costs of patent actions it is idle to deny that the inventor, even the small capitalist, is in no position to fight for his rights as against a powerful and wealthy corporation. Under our system it is perfectly possible for an inventor who is possessed of undoubtedly valid patent rights of very great value to be put to an expense of many thousands of pounds in establishing himself before the Courts of the Kingdom. To take one instance only, the great German colour firms such as the Badische Anilin und Soda Fabrik have attained a complete mastery over the English dye trade. They control by their British patents every dyestuff which is of any value for the time being, and should an English firm desire to contest the validity of these monopoly-rights they must be prepared to shed money like water until finally they reach a decision before the august tribunal of the House of Lords.

As a result the vast bulk of the dye-stuffs which are so largely used by English textile manufacturers are made in Germany and sold here at a price which is practically within the arbitrary control of the particular firm who possess the patent. It follows that the dye-trade has languished here, since no English chemist is willing to risk the big sums which would be necessary to break down the wall of intimidation which British gold has been so largely instrumental in erecting. Clause 27 has been designedly framed to meet this case, since it was to the dye industry that the President of the Board of Trade directed himself in introducing the Bill. It is contemplated either that the German dye-makers must establish factories in this country, and so at least pay back in wages some of the money which has flowed from Yorkshire, Lancashire, and the Tweed, for so long, or permit their monopolies to expire in favour of home manufacturers.

Will it be successful? The experience of foreign countries is not altogether encouraging. The degree of compulsory working demanded is frequently of so meagre a character that no practical result ensues. As an example, in Austria it suffices if the inventor advertises his patent for sale in the public journals prior to the date of the clause coming into operation, and it is said that such an advertisement is usually regarded as being a mere formality intended neither by the grantee of the patent nor by anyone else as a genuine invitation to buy. In some cases the smallest description of working is sufficient to ensure an immunity.

It really depends entirely upon the construction which the Comptroller of the Patent Office places upon the clause. If, as seems likely, he avails himself of the wide character of the words to insist on that full measure of protection which was designed by the eminent draughtsman of the Act, it may well be that British industries will have to thank the Free Trade Government of 1905 for the first measure of protection they have enjoyed since the days of Cobden.

Perhaps the most instructive light on the probable effect of the provision is to be obtained from the course now being pursued by the persons most nearly involved. It is openly stated that at least one of the great German corporations involved in this trade is actively engaged in preparing for the erection of large works in this country in compliance with the provisions of the Act. Should this eventually prove to be true, Mr. Lloyd-George will have earned from all parties, irrespective of political opinion, a tribute of praise and admiration for his patriotic and courageous statesmanship.

Clause 19 of the Act introduces another foreign element, which, in the opinion of those best qualified to judge, is of the highest utility. It consists in the creation of so-called patents of addition. A patentee in France has been entitled to this privilege for years, and the advantage both to inventor and public has been so marked that the introduction of this feature into our Patent Law has long been advocated by those expert in the subject.

A person who has obtained a patent now, and subsequently discovers important modifications, which he desires to protect, will be enabled to do so without fear of having the subject-matter of his new patent called in question. The price paid for this favour is the loss of monopoly period comprised within the dates of the parent patent and the patent of addition. The latter will be appendent to the former, and by sacrificing the intervening years (though it is not wholly clear in the opinion of the writer) a statutory guarantee that there is patentable subject-matter is obtained. Supposing in 1908 an invention for an induction-motor is obtained, and in 1910 an important detail improvement is effected, which largely enhances the utility of the original construction, a patent of addition is obtained for the novel idea dated back to 1908. Both patents will expire in 1922, whereas under the old Act a new patent must have been applied for, expiring in 1924. The patentee has lost the monopoly between 1922 and 1924, but gained the very substantial consolation that as against his patent of addition no trade rival can be heard to urge that it is invalid by reason of defect in subject-matter. It is further provided that

> "The grant of a patent of addition shall be conclusive evidence that the

> invention is a proper subject for a patent of addition, and the validity of the patent shall not be questioned on the ground that the invention ought to have been the subject of an independent patent."

It should be remarked that as regards the large bulk of the Act it is a mere codification and re-enactment of those measures known as the "Patents, &c., Acts, 1883-1901." In the short limits of this article it is only possible to deal with those features which are substantial innovations.

The attack upon a patent in a court of law frequently contained, in the days before the Act, the objection technically known as "disconformity." It is probable that this thorn in the side of the patentee, so often successfully (and perhaps unfairly) urged against the validity of his patent, will be less constantly in evidence in the future.

Section 42 of the Act runs as follows:

> "A patent shall not be held to be invalid on the ground that the complete specification claims a further or different invention to that contained in the provisional, if the invention therein claimed, so far as it is not contained in the provisional, was novel at the date when the complete specification was put in and the applicant was the first and true inventor thereof."

How often has it happened in the history of invention of recent years that an inventor who has a really meritorious idea rushes into a provisional specification without fully satisfying himself as to the working details and methods of his idea? Before the time arrives for filing his complete specification it happens in a vast number of cases that some simpler and better procedure or even an extension of the original invention is discovered by experiment. Prior to this Act the inventor was on the horns of a dilemma. He could either put all into his complete specification and run the risk of having the patent declared invalid by reason of "disconformity"—or he could leave out the newly acquired matter and rely upon a new patent for protecting what was not in his first complete. He can now put his new ideas into his complete specification with a lighter heart. He has only one danger to guard against, that some person has protected the subject of his added matter in the interval between provisional and complete protection.

The precise effect of this provision is still a matter of considerable debate in the profession. The general opinion appears to be that it will be of considerable utility. In the view of the writer it will eventually be found to leave matters pretty well as they were, for the good reason that inventors and patent agents who are about to protect a valuable idea will not run the risk of a provisional or complete specification intervening which by the terms of the section would revive the objection of "disconformity."

The last matter which it will be possible to review here is the new power of the Patent Office to revoke patents in certain specified instances. Prior to this Act a patent could only be revoked by order of the High Court on petition—a process costly in itself and generally involving questions of the *locus standi* of the petitioner which were only to be settled with safety by obtaining the *fiat* of His Majesty's Attorney General.

Section 26 of the new Act is designed to provide in some cases a cheaper and speedier method. It runs as follows:

> "Any person who would have been entitled to oppose the grant of a patent, or is the successor in interest of a person so entitled, may, within two years from the date of the patent, in the prescribed manner, apply to the Comptroller for an order revoking the patent on any one or more of the grounds on which the grant of the patent might have been opposed," &c.

The undoubted result of this section will be to cause a large volume of litigation before the officials of the Patent Office. The cost of a revocation proceeding before the Comptroller may be confidently estimated as only a fraction of the cost of a petition to the High Court, and many a commercial firm may well adventure the necessary money to get rid of the incubus of an invalid patent belonging to a rival, which, despite its unreality, is still a very potent weapon in the race for trade. It is very certain that not nearly a half of existing patents in working use are valid. Hitherto the serious nature of the undertaking has prevented revocation proceedings from attaining any large dimensions. It remains to be seen whether the new procedure will open the way to an extinction of the invalid and voidable patent on a much larger scale. It should be borne in mind that the matter can be carried as far as the House of Lords should either party desire.

Such are some of the more salient features of Mr. Lloyd-George's Act. Years of working will be necessary before the practice is settled and a fair idea of the value of the changes introduced can be formed. But it is at least competent to observe now that the wishes of the great commercial interests involved have been carefully considered and, where possible, met, and that whatever the outcome, a real effort has been made to remove the hampering restrictions which have been a handicap to the British manufacturer in the past, and to provide machinery for fostering so valuable a national asset as invention in the future.

* * *

COST OF POWER PRODUCTION.*

I. V. ROBINSON, Wh.Sc.

SINCE the electrical transmission of power through great distances became an accomplished fact, water power has been developed very considerably; new centres of industry have been formed in the neighbourhood of these new sources of power, and new processes have been placed upon a commercial basis. There are now many manufacturing processes which require as an essential factor for their commercial success a large amount of cheap power. Amongst these we may mention the manufacture of aluminium and calcium carbide, both of which are now being carried out upon a very extensive scale. Another process that requires a large amount of power is the electrical production of steel. The development of water power has rendered possible the manufacture of steel in many districts where ore is available but no coal at hand for smelting purposes.

A process that is likely to see considerable developments within the next few years is the manufacture of nitrogenous manures by the fixation of atmospheric nitrogen. This problem has been attacked by many chemists, and one of the most successful methods in use at the present time is that patented by Messrs. Birkeland & Eyde. They started with an experimental laboratory at Vermoen, near Arendal, in Norway. At a later date they established a factory on a commercial basis at Notodden, Sweden, and this plant has now been considerably extended. The author believes that they propose utilizing at Svaelgfos some 30,000h.p. for the development of this process.

Until the development of water power on a large scale, coal was used almost exclusively for power generation, and all industries naturally located themselves in the neighbourhood of a supply of cheap coal. This neighbourhood was well provided with transport facilities and was naturally the best centre for manufacturing purposes. It will be noticed that coal-mining districts in Great Britain are in every case the most densely-populated portions of the kingdom, with the exception of London. With the development of water power other new centres of industry are being formed. Niagara has rapidly become the centre of many industries, and the same can be said of many of the Italian rivers, such as Pescara, Bormida, &c.

There is one important difference to bear in mind when comparing power obtained from water and from coal. The coal is the result of the action of the sun in remote ages, and there is only a certain quantity of this fuel available. The flow of water down rivers and over falls is a direct result of the action of the sun at the present time, and will, therefore, go on as long as the action of the sun continues. It might thus be said that in using water for generating power only income is being spent, but in the utilization of coal there is an encroachment upon capital.

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*Abstract of paper read before the Institution of Engineers and Shipbuilders in Scotland, January 21st, 1908.

The recent Royal Commission on Coal Supplies stated that there was sufficient coal in sight to last a very considerable period, but it is still of interest to consider what the result would be of the complete working out of the coal fields in Great Britain. The centre of power becomes the centre of industry, and in that case the industries would naturally be transferred to a district where water power is available. As regards water power, Great Britain is very badly situated and has no falls or rivers from which the power now in use could be generated. There are a few large water-power plants in Great Britain, such as those at the Fall of Foyers, Loch Leven, Snowden, &c., but these are only small when compared with those that have been developed upon the Continent and in the United States. If there were no coal available all engineering industries would cease, as there would be no means of manufacturing iron and steel. Should, therefore, the British coal supply run out, Britain would be dependent upon other countries for practically all her necessities, and eventually would fall out of the manufacturing world and perhaps become a solely agricultural nation. It is, therefore, a very important matter to economize fuel in every way possible, but any economy will only postpone and cannot avert the time when Britain's coal supply will become exhausted.

Owing to the recent development of the large gas engine, a considerable amount of power can be generated from the waste gases of blast furnaces and coke ovens which are at present being blown into the atmosphere. Of the total output of gas from the blast furnaces a certain proportion is required for heating the stoves and providing the necessary power for use about the furnaces. The amount of gas to spare depends entirely upon the plant that is installed at the furnaces. If there are steam blowing engines and steam is generated in gas-fired boilers there is not much gas to spare, but by the use of gas-driven blowing engines a large amount of surplus power is rendered available. It has been estimated that the blast furnaces of Great Britain could provide power to a total of at least 1,136,000h.p. From the waste gases of the coke ovens which provide coke for the blast furnaces, a total of 350,000h.p. could be obtained.[*]

The adoption of the gas engine under these circumstances would, therefore, render available about 1,500,000h.p. in Great Britain.[†] This power could be generated at a cost that would compare very favourably with water power.

In comparing these two sources of power, account should be taken of the fact that water power is very often in a district remote from transport facilities, and extra expense is incurred in transferring the finished article to the market. On the other hand blast furnaces are always situated in the middle of a busy district, and the manufactured article may actually be made in the market.

The author, therefore, compares the cost of power generated by gas and by water, as it appears that for generation of power in large quantities from coal, gas engines will be almost exclusively used. The mechanical difficulties that were experienced with large gas engines have now been overcome, and a large gas engine can be obtained that will run with every satisfaction and reliability.

One point in which the steam turbine has a decided advantage over the gas engine is in the space occupied and the total power of units. Steam turbines may be obtained to give anything up to, say, 12,000kw. in one unit, whereas gas engines cannot be built for a greater output than about 3000-4000kw. The capital cost of a steam-turbine plant is less than the cost of a gas-engine plant using producer gas. Where the fuel to be used is either blast-furnace or coke-oven gas, the gas engine plant costs practically the same as the turbine plant, owing to the latter requiring gas-fired boilers, condensing plant, and a much larger cooling tower where a natural supply of water is not available.

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[*] L. Greiner gives the following approximate rule for the amount of power available for external use:—

(a) With blast furnaces, the continuous available horse power is equal to the number of tons of iron made per month.

(b) With by-product recovery ovens, the continuously available horse power is equal to the number of tons of coke made per week.

Paper read before the Liége Association of Engineers, March, 1907.

[†] It may be interesting to calculate the cost of the coal that would be saved by the complete utilization of these waste gases. A consumption of 3lb. of coal per b.h.p. per hour is a fair average, and for all classes of engines central power station plant uses about 3lb. per kw.-hour, and engines in old mills, &c., may use as much as 6lb. per b.h.p. per hour. With coal at 6s. per ton, the cost of coal per h.p. per year is about £3 10s. 0d., or for the full amount of power £5,250,000. Allowing for a load factor of 25 per cent., the annual cost of coal which might be saved is about £1,312,500.

Owing to this higher initial cost, producer-gas engines are not more economical than steam-turbine plant in cases where there is a low load-factor. Dealing chiefly with the question of supplying power for electro-chemical and electro-metallurgical purposes, the author confines himself to gas engines, as they are more economical than steam turbines when they are working on a high load-factor, such as is obtained in work of this nature.

Take for purposes of comparison a power-station designed for a continuous output of 20,000b.h.p. and estimate its capital cost, assuming (1) that waste gas from blast furnaces is available, and (2) that gas producers, and with them ammonia recovery plant, have to be provided. With these capital costs it is proposed to compare the costs of water-power stations of about the same output. In an estimate of this nature it is impossible to allow, except by including power transmission lines, for the fact that the water-power station may be in a comparatively remote district and that transport of raw material and finished products will be more expensive.

As an up-to-date example of a water-power station, the author gives some information of the cost of equipping two stations on the River Aveto in Italy, by the Societa Idro-elettrica Ligure, Milan. This river has its source on the north side of the Ligurian Apennines and is a tributary to the River Po. The Apennines are situated comparatively close to the coast of Genoa Bay, and there is, therefore, a rapid fall from them on the south side. On the north side the fall is more gradual, and the water from storage reservoirs in the hills would have to be conveyed a great distance to obtain a reasonable head. To reduce the capital cost, Professor Zunini of Milan suggested tunnelling through the hills, and placing the power stations on the south of the hills. By this means a rapid fall has been obtained and the expense on pipe lines reduced to a minimum. Owing to the total head available being so great it has been decided to divide the fall between three power stations. The first station will generate 28,000h.p., with a fall of 1150ft.; the second 17,500h.p., with a fall of 625ft.; and the third 12,000h.p., with a fall of 550ft.

The total cost of the first and second stations is estimated to amount to £640,000, or slightly over £14 per horse power developed. The cost is divided amongst the various items as follows:—

Purchase of land	£80,000
Rebuilding of roads, schools, churches, and houses	40,000
Compensating reservoirs, &c.	60,000
Power reservoir and water course, including tunnels, sluices, gates, penstocks, &c.	160,000
Pipe lines	60,000
Masonry for power houses	32,000
Hydraulic machinery	20,000
Electric machinery, including switchboards, generators, and step-up transformers	60,000
Transmission lines	68,000
Step-down transformers and secondary distribution	60,000
	£640,000

It will be noticed that this estimate includes the cost of the transmission line, transformers, and distribution system. For a comparison with a gas-power station the cost of the transmission line and transformers should be included. As the power station has to be built where the water is available, in the comparative cost must be included all expense entailed in bringing the power to the place where it is required. It is not necessary to include the distribution system, as for electro-chemical or electro-metallurgical work this would not be a very large item, such work usually being placed close to the power station or sub-station: assume that £40,000 has been allowed for this item, reducing the capital cost to £600,000, or £13 4s. 0d. per h.p. developed.

Owing to the electrical loss in the transmission line the whole of the power generated is not delivered at the consuming point. This loss varies with the length and section of the transmission lines, and may be anything from 5 to 20 per cent. for long lines. If it be assumed in this case that the loss is 10 per cent., then the capital cost per h.p. delivered is about £14 13s. 0d.

In a report recently issued by the Mexican Light and Power Co. it is stated that the Company proposes the erection of a second water-power station to contain six units of 8000h.p. each. The first unit will cost £156,500, this apparently including the building of the complete station, etc., as each additional unit will only cost £52,100. The total cost of the station containing in all

48,000h.p. will be £417,000, or about £8 14s. 0d. per h.p. developed.

Water power is very abundant in Canada, and a Commission was appointed some time ago to report to the Canadian Government regarding the power obtainable in the Province of Ontario, the cost of developing it, the probable market for it, and the price at which it would be supplied. In the reports issued by this Hydro-electric Power Commission full details are given of the cost of developing many large water-power schemes, and, as an example, the Cameron Rapids Development is here cited. The following details are abstracted from the fifth report of the Commission. All prices have been converted from dollars to pounds ($4.85 = £1).

It is estimated that the Cameron Rapids are capable of developing 16,350h.p., and that the bulk of this power would be transmitted to Port Arthur and Port William, 75 miles away. The Commission's chief engineer reports as follows regarding the scheme:—

> "The power is situated on the Nepigon River about 14 miles north of Nepigon Station. The very considerable importance of this power is due to the fact that it is within transmission distance of Port Arthur and Port William, and that it is available for the development of the extensive pulpwood areas of the Nepigon watershed. In addition to this, the remarkably favourable topographical condition in the neighbourhood of the power site and the magnificent storage facilities offered by Lake Nepigon with its 1500 square miles of area, which would obviate all necessity for artificial regulation for some time to come, combine to make this a most attractive proposition from an engineering standpoint."

The estimates are based on information collected by the Commission's engineers, and on such other information as was available and known to be authentic.

In estimating the total working costs the Commission has allowed for the renewal of the so-called permanent works, such as dam, headworks, power house, etc., in 40 years, and of the transmission and transformation plant in 15 to 30 years. Interest on capital has been allowed for at 4 per cent.

The capital cost of the complete generating station, including all the headworks, etc., is estimated to be £168,300, or £10 6s. 0d. per h.p. developed.

The transmission line is estimated to cost £1145 per mile, made up as follows:—

Equipment..	£933
Right of way protection	21
Engineering and contingencies	191
	£1145

Total capital cost of 75 miles, £85,800.

Owing to the transmission line resistance, there will be a loss of 1900h p., or 11.6 per cent. The cost of the transformation station is also given, but this will not be taken into account.

The estimated annual generating and transmission expenses for the Cameron Rapids scheme are given as follows:—

Wages, labour, etc.	£3380
Maintenance and repairs	3575
Replacement fund	3450
Administration	1000
Interest at 4 per cent.	6715
Total generating expenses	£18,120

Power generated=16,350h.p.
Generating expenses per h.p. per year=£1 2s. 3d.

Transmission Expenses per Mile.

Interest, maintenance, repairs, and replacement fund	£63	0	0
Right of way protection..	1	2	6
Engineering and contingencies	12	17	6
	£77	0	0
Total capital charges for 75 miles	£5765	0	0
Patrol of line	465	0	0
Total transmission expenses	£6230	0	0

Power transmitted=14,450h.p.
Total generating and transmission expenses=£24,350.
Generating and transmission expenses per h.p. per year=£1 13s. 8d.

In the above estimate interest is allowed at 4 per cent. In the gas-engine estimate the interest allowed is 5 per cent. With the higher rate the above estimates became as follows:—

Generating expenses per h.p. per year =	£1	4	3
Generating and transmission expenses per h.p. per year =	1	17	3

Some remarkable figures have been recently published by Professor S. P. Thompson regarding the cost of water power used at Notodden for the Birkeland & Eyde nitrogen-fixation process. He states that the total costs per unit are .025d., and that they will be .0151d. at the new power station at Svaelgfos. The figures are equivalent to 13s. 7d. and 8s. 3d. per h.p. per year respectively. No information is given as to whether this includes replacement fund charges, interest on capital, &c.

Various estimates of the cost of water power have been made, and the capital cost and cost per horse power per year for a number of schemes are given in the following tables.

TOTAL COST PER HORSE POWER PER YEAR.

Situation.	Price.			Remarks.
Svaelgfos, Norway	£0	8	3	No transmission costs included. No information regarding capital charges, &c.
Notodden, Norway	0	13	7	No transmission costs included. No information regarding capital charges, &c.
Cameron Rapids, Ontario	1	2	3	Total generating costs. Interest 4 per cent.
Do do.	1	4	3	Total generating costs. Interest 5 per cent.
Do. do.	1	13	8	Total generating and transmission costs. Interest 4 per cent.
Do. do.	1	17	3	Total generating and transmission costs. Interest 5 per cent.
Toronto, Canada	2	17	9	Hydro-electric Power Commission's offer delivered to Corporation's boundary from Niagara.
Horahora Rapids, New Zealand ..	3	0	0	Proposal of Waihi Gold Mining Company.
Montreal, Canada	3	3	0	Average price obtained by Shawinigan Water and Power Co. for 19,000h.p. delivered in Island of Montreal.
Montreal, Canada	3	18	6	Montreal firm's contract with Shawinigan Water and Power Company for 3250h.p.
El Oro Gold Mines, Mexico	10	0	0	Purchase price of power transmitted 76 miles from Nexaca Station of Mexico Light and Power Co.

(See appendix for table of capital cost of hydro-electric schemes.)

Equipment of Gas-engine Power Station.

Size of Unit.—Engines capable of developing 4000b.h.p. as a normal load and 5000b.h.p. as a maximum load have recently been set to work in America. It is stated that the Californian Gas and Electric Corporation, San Francisco and Oakgate, have two units of this size at work, and another in course of erection. The United States Steel Trust have recently placed an order for thirty-six engines of 4000b.h.p. capacity each for their various works (twenty-five for the new Gary Steel Works, at Gary, Indiana, seven for the Carnegie Homestead Works, Pittsburg, and four for the South Chicago Works, Illinois Steel Co.). These engines are of the four-cylinder, twin-tandem, double-acting type, and some are direct-coupled to 25-cycle alternators, the remainder driving blowing cylinders. The cylinders are 42in. in diameter by 54in. stroke, and the speed is 83.3r.p.m.

The largest gas-engine cylinder working in Great Britain has a diameter of 1200 millimetres, or about 51¼in. The stroke of this engine is 1400 millimetres, or about 55in. There are several engines at work now with this size of cylinder, but they are all of the single-cylinder, single-acting type. The larger the cylinder the more difficult it is to make it sufficiently strong. It becomes heavier, more awkward to design, manufacture, and handle, and the cost per horse-power developed would probably increase with larger sizes of cylinders. The double-acting gas engine is now a success, and the size of the cylinder is thereby considerably reduced. The latest practice is to have tandem double-acting cylinders even for driving blowing cylinders, as this reduces the maximum force exerted by each explosion.

The tandem double-acting engine runs with sufficient regularity to drive 25-cycle alternators in parallel with a moderate fly-wheel capacity. For driving 50-cycle alternators in parallel it would be advisable to install twin-tandem engines with the two cranks at right angles. It is possible to drive them in parallel (many plants of this nature are at work) with single-crank engines, but a greater fly-wheel capacity is required in the fly-wheel and generator.

A number of engines have been installed in Great Britain having double-acting cylinders 39½in. in diameter by 43½in. stroke (1000 millimetres by 1100 millimetres), and the author takes engines with this size of cylinder as the unit in the power station. A twin-tandem engine fitted with this size of cylinder would be capable of giving a continuous output of about 2850b.h.p. when running at 94r.p m. To ensure being on the safe side, the normal full load will be taken at 2500b.h.p. and eight engines will be installed for the full load of 20,000b.h.p. A ninth would be installed as a spare unit, although it should be noticed that seven units running at 2850b.h.p. would practically give an output of 20,000b.h.p. With nine engines installed the station really has two spare units.

Generators.—For many electro-chemical and electro-metallurgical processes continuous current is required, but for the fixation of the atmospheric nitrogen by Birkeland & Eyde's method a large proportion of the power is required as alternating current. Generators of either type would be mounted on the shaft between the two lines of cylinders. If generators of both types were required it would be advisable to install two motor generators, each capable of supplying all the current required for exciting the alternators and working the various small motors about the station. Where all the generators are of the alternating-current type, a small gas engine driving a dynamo should be installed in place of the second motor-generator. When this station is to be started up with all units standing, the small engine would be put to work and would provide the excitation required for the large alternators. After these were running on load, the motor-generator taking high-tension, alternating current on one side could provide the excitation, &c., and the small engine could then be shut down.

Foundations.—The foundations for a gas engine are generally more expensive than those required for a steam turbine. A water-power station requires much more expensive foundations owing to the channels that have to be provided for the passage of the high-pressure inlet water and also for the escape of the water from the turbo. For a gas engine it is advisable that the total weight of concrete foundations should be equal to about six times the maximum force exerted on the piston during one explosion. With a two-line engine they should be heavier than this, as the concrete is spread over a larger area than with a single-line engine, and the maximum explosive force is equal to that obtained in a single-line engine with similar cylinders.

Engine House.—Each of the 2500b.h.p. engines would require a clear ground space of approximately 40ft. wide by 60ft. long. The width is measured over all gear attached to the engine and the length from the end of the piston-rod rear support to the frame of the generator. Allowing for 10ft. clear between adjacent engines and 15ft. at either end of the house, the total length of the house will be about 470ft. The width should be at least 80ft. There should be sufficient space between the two lines of cylinders in each engine for the motor-generator, air compressing plant (for starting the engines), jacket-water circulating pumps, &c. The switchboard should be placed upon a gallery from which the whole station could be seen.

The engine house should be a steel structure filled in with brickwork between the columns. As far as possible it should be built so as to exclude dust.

Gas-cleaning Plant.—Gas-cleaning plant for blast-furnace gas varies according to the fuel used in the furnace. In Scotland where bituminous coal is the chief fuel, there is a lot of tar remaining in the gas after it has passed through the by-product plant. This tar has been successfully removed by a cleaner introduced by the Summerlee Iron Company. The gas is made to pass through a number of narrow orifices and to impinge upon an inclined surface when moving at a high velocity. The heavier tar adheres to the surface and runs down to an inclined tray, from which it is removed at intervals.

In the Summerlee cleaner, the gas is drawn through the orifices by the suction of the gas cylinder when the engine drives a blowing cylinder. The gas reaches the cylinder under a vacuum of from 6in. to 12in. water gauge, according to the atmospheric conditions. For electric power gas engines it is advisable to force the gas through the cleaner by a centrifugal fan, to avoid any variation in the suction pressure and to ensure a more regular speed.

Where coke is used as the fuel in the blast furnace, there is no tar, and the chief trouble is dust. The Theisen gas cleaner has proved successful in removing dust, and consists of a motor-driven cylindrical drum fitted with projecting vanes. Water and gas enter the annular space round the drum at opposite ends, and the water removes the dust. The gas then passes into a vapour-separating chamber and is thoroughly dried. During a three months' test with a Theisen cleaner the quantity of dust contained by the emerging gas varied from .0019 to .0043 grammes per cubic metre, *i.e.*, .0019 to .0043 ozs. per 1000 cubic feet; about half a litre of water was used per cubic metre of gas, or about 6¼ gallons per 1000 cubic feet. Other forms of gas-cleaning apparatus have been developed by Mr. B. H. Thwaites—the pioneer in Great Britain of the use of blast-furnace gas in internal combustion engines; the Power Gas Corporation, Mason's Gas Power Company, Zchocke, Sahlin, and others.

Capital Cost of 20,000b.h.p. Gas-engine Power Station using Blast-furnace Gas.

The approximate total cost of the complete power station is given in the following table. The cost of the various items per b.h.p. is compared with an estimate given by M. Leon Greiner in his paper previously mentioned. M. Greiner's total cost per b.h.p. is not divided into similar subdivisions to those adopted here, but the total per b.h.p. is practically equal in both cases.

		Cost per b.h.p. according to this estimate.	M. Leon Greiner's.
Nine twin-tandem double-acting gas engines to develop 2500b.h.p. at 94 revs.	£112,500	£5 12 6	£4 14 0
Nine 50-cycle 5000-volt three-phase alternators for direct-coupling to gas engines ..	26,000	1 6 0	1 11 4
Centrifugal-type gas-cleaning plant	12,000	0 12 0	1 11 4
Switchboard, motor-generators and connections to alternators	10,000	0 10 0	—
Engine house, 470ft. by 80ft. steel structure, brick-filled, with 20-ton crane	24,000	1 4 0	1 11 4
Foundations for gas engines and engine house, about 14,000 cubic yards	14,000	0 14 0	0 10 5
Cooling towers for jacket-water, 300,000 gallons per hour	2,000	0 2 0	—
Water pumps, air compressor, and reservoir for starting gas engine	1,500	0 1 6	0 10 5
ncidentals and supervision	11,000	0 11 0	—
	£213,000	£10 13 0	£10 8 10

Capital. Cost of 20,000b.h.p. Gas-engine Power Station using Producer Gas.

The equipment of the station would not be altered except that a gas-producing and ammonia-recovery plant would be substituted for the gas-cleaning plant. The capital cost of this plant complete with all producers, gas cleaners, ammonia-recovery towers, exhaust-gas-heated boilers for supplying steam required by producers, would be about £75,000 or £3 15s. od. per b.h.p. The total cost of the station would be £276,000 or £13 16s. od. per b.h.p., as compared with £10 13s. od. for the blast-furnace-gas station. There would be two coal-fired Lancashire boilers for providing steam when the plant is starting up from all standing, and if all boilers were of this type instead of the exhaust-gas-heated boiler, the total price would be reduced by about £4000.

Cost of Generating Power by Gas Engines.

The total cost of generating power by any means consists of two portions: (1) the working expenses, such as fuel, oil, labour, repairs, maintenance, and superintendence, and (2) the capital charges comprising interest on the total cost of the generating plant and sinking-fund charges for redemption of capital.

With a gas engine the first portion is low owing to its high thermal efficiency, and the second item is higher than for steam-turbine plant owing to the heavier initial expense. With water power the second item constitutes the bulk of the total cost owing to the generally very heavy initial cost and the fact that no fuel is required.

Some interesting figures were given in M. Greiner's paper regarding the working costs of Messrs. Cockerills' own central gas-power stations. The larger station contains in all six engines, aggregating 7000b.h.p. and using blast-furnace gas. In the other station are two engines using coke-oven gas and having a combined output of 1000b.h.p.

In 1900 all electric power required in Messrs. Cockerills' works was generated by steam engines with a total capacity of 1000kw. Commencing in 1901, they gradually replaced their steam engines by gas engines, and owing to the success of the initial engines they largely increased the number of motors in use. By 1906 all the steam engines were removed and they had gas engines in use developing 5700kw.

In the following table the total working costs per b.h.p. per hour are given for each year. The steam plant was not of the most modern type, but the most up-to-date steam turbine plant would not be able to approach the figures given for 1906-7.

Year.	Plant.	Units per annum.	Working costs per b.h.p. per hour.
1900-1	Steam only	1,789,781	.629d.
1901-2	Gas and steam	1,930,740	.554d.
1902-3	do.	2,007,290	.428d.
1903-4	do.	5,387,612	.212d.
1904-5	do.	9,999,216	.147d.
1905-6	do.	14,915,919	.116d.
1906-7	Gas only	24,000,000	.047d.

The output for 1906-7 of 24,000,000 units corresponded to a load factor of 50 per cent. calculated upon a full year of 8760 hours. All working costs for a large blast-furnace gas-engine plant are practically independent of the average load of the engine. Lubrication and attendance are almost the same at all loads, but the cleaning and repairs may be increased with the load. With a higher load factor, the working costs per unit are thus decreased. M. Greiner gives the following figures based upon his experience:

Load factor.	Working costs per b.h.p. per hour.
25 per cent.	.0864d.
50 „	.0465d.
75 „	.0311d.
100 „	.0233d.

For a load factor of 95 per cent., which may be attained in electro-chemical or electro-metallurgical works, the total working cost per b.h.p. per hour would be about

.024d. On analysis of the working costs it was seen that they could be divided approximately as follows:—

Labour, including engine attendants, generator and switchboard hands, &c., superintendence, &c.	45 per cent.
Lubrication	20 "
Cleaning, upkeep, and repairs	35 "

With a total cost per b.h.p. per hour or .024d., the above three items amount to .0108d., .0048d., and .0084d. respectively.

The fixed charges depend upon the useful life, the capital cost of the plant, and the interest to be paid upon this capital. Large gas engines have not been in use yet for a sufficient length of time to say from experience what useful life they will have. As this has a very great effect upon the fixed annual charges, three cases are taken, assuming that the life is (1) 10 years, (2) 15 years, and (3) 20 years. It is necessary to allow only the same useful life to the alternators and foundations, as they might not be utilised for new gas engines.

For the gas-cleaning plant, switchboard, motor-generators, &c., a useful life of 15 years may be taken. A 20 years' life is assumed for the water pumps and air compressors, but only 12 years for the cooling towers, depending upon the quality of the timber used in their construction. The engine house should last at least 40 years. For depreciation the author assumed that a sinking fund would be formed, and that 3 per cent. compound interest could be obtained upon annual payments. For the engine house a separate sinking fund should be formed owing to its life being so much longer than the other items. To obtain the period in which the sinking fund should mature, the cost of each item is multiplied by its allowable life, and the sum of these products is divided by the total capital cost. The annual payment to the sinking fund for the engine house amounts to £310 per annum. For the remaining items in the blast-furnace station £189,000 has to be redeemed in 20 years for the longer life of the engine, &c. For the 15 years' life the equated period is 15.35 or, say, 15 years, and for the 10 years 11.3 or, say, 11 years. The annual payments are £6820, £9810, and £14,280. In addition to the sinking fund there is the interest on capital to be allowed at the rate of 5 per cent. per annum.

The station is assumed to work at an average load of 19,000b.h.p. for 8760 hours per year, or at a load factor of 95 per cent. The output is then 166,000,000b.h.p. hours per annum.

With this output the total annual working costs of the blast-furnace gas-engine station will be as follows:—

ITEM.	LIFE OF PLANT.		
	20 years.	15 years.	10 years.
	£	£	£
Labour 166,000,000 at .0108d. ..	7,470	7,470	7,470
Lubrication 166,000,000 at .0048d.	3,320	3,320	3,320
Cleaning and repairs 166,000,000 at .0084d.	5,810	5,810	5,810
Works cost	16,600	16,600	16,600
Sinking fund, engines, &c. ..	6,820	9,810	14,280
Do. house	310	310	310
Interest	10,650	10,650	10,650
Total costs	34,380	37,370	41,840
Cost per b.h.p. per year	£1 14 4	£1 17 4	£2 1 10

To estimate the cost of power generated by a gas engine power station using producer gas, the extra net cost of the gas has to be added to the expenses previously indicated. There are several gas plants at work producing gas equivalent to upwards of 20,000b.h.p., but the major portion of the gas in all the plants is used for heating purposes. Producer gas used in heating furnaces is similar to that used in gas engines, except that it is not cleaned to the same extent. From experience gained with these large producers, it appears that the total cost of producer gas for engines with a capacity of 20,000b.h.p., working with a 95 per cent. load factor, will be as given in the following table. Coal has been taken at 7s. 6d. per ton, although an ordinary price for fuel of a suitable grade in the Glasgow district is 6s. per ton. The coal consumption per b.h.p. per hour has been assumed at 1.2lb., or 1.6lb. per kilowatt hour. This includes the raising of all steam required for the ammonia-recovery plant, &c. The yield of sulphate of ammonia per ton of fuel has been taken at 92lb. This figure depends upon the composition of the coal and is a fair average value. The market price of sulphate of ammonia has ranged from £12 to £13 5s. 0d. per ton during the last six years and is now £12 5s. 0d. The sale price of the sulphate of ammonia obtained from the gas has been assumed to be £11 per ton instead of the market price. The higher price would be more favourable to the cost of producing the power.

For the ten years' life of the engine the sinking fund has to mature in twelve years, owing to the fact that a fifteen years' life is allowed for the gas-producing and ammonia-recovery plant.

Labour at the gas plant	£5.300
Acid, stores, repairs, &c.	9.300
Water	770
Fuel—89,000 tons at 7s. 6d. per ton	33.375
	£48,745
Less 3.660 tons of ammonium sulphate at £11 per ton	40,260
Nett cost of gas	£8,485

	LIFE OF PLANT. 20 years.	15 years.	10 years.
Works costs (excluding fuel)	£16.600	£16.600	£16.600
Nett cost of gas	8,485	8,485	8,485
	25.085	25.085	25.085
Sinking fund, engines, &c. ..	9.200	13.480	17.700
Do. house	310	310	310
Interest	13.800	13.800	13.800
	£48.395	£52.675	£56.895
Cost per b.h.p. per year	£2 8 5	£2 12 8	£2 16 11

The various estimates given for the cost of gas-engine power are collected in the following table :—

<table>
<tr><th>Gas used.</th><th colspan="3">Cost price per h.p. per year.</th><th>Life of plant</th></tr>
<tr><td>Blast furnace</td><td colspan="3">£1 14 4</td><td>20 years.</td></tr>
<tr><td>do.</td><td colspan="3">1 17 4</td><td>15 ,,</td></tr>
<tr><td>do.</td><td colspan="3">2 1 10</td><td>10 ,,</td></tr>
<tr><td></td><td colspan="3">Price of coal per ton.</td><td></td></tr>
<tr><td></td><td>6s.</td><td>7s. 6d.</td><td>9s.</td><td></td></tr>
<tr><td>Producer gas</td><td>£2 1 9</td><td>£2 8 5</td><td>£2 15 1</td><td>20 years.</td></tr>
<tr><td>do.</td><td>2 6 0</td><td>2 12 8</td><td>2 19 4</td><td>15 ,,</td></tr>
<tr><td>do.</td><td>2 10 3</td><td>2 16 11</td><td>3 3 7</td><td>10 ,,</td></tr>
</table>

In comparing gas and water power, the reliability of the supply should be taken into account. The gas-engine station can fail either by the breakdown of the plant or shortage of fuel. The former is guarded against by careful design and the installation of spare plant. Labour trouble might cause a temporary shortage of fuel.

The water-power station might cease to supply power from either of the above reasons, the fuel in this case being the water. Careful design and spare plant are relied upon to overcome breakdowns. The water supply to the station may be interfered with by the formation of ice. Some interesting information on this point was given in a paper read by Professor H. T. Barnes, of Montreal, before the British Association recently. From this it appears that the most troublesome form of ice is the frazil ice, which forms in thin plates and crystals in turbulent waters. This changes into large spongy masses which adhere to the metallic portions of the turbines and eventually choke them. This may sometimes be prevented by local heating of the turbo casing, so that the masses of frazil ice are unable to adhere to the metal.

Where the water, on its way to the power station, passes from a turbulent portion of the stream through a quiet pool which freezes over during frost, the frazil ice acts in a different way. It rises under the surface sheet of ice in the quiet pool and becomes attached to it. This action may eventually choke the passage under the ice, and the water in that case rises behind the ice and may force the whole mass down to the power station intake.

Anchor ice forms on the ground due to heat radiation during cold nights. Frazil ice becomes attached to this and forms large masses. With a slight rise in temperature the anchor ice rises to the surface, often carrying large stones, boulders, &c., with it. These may cause considerable trouble in the water turbine. In many situations ice may thus cause considerable trouble to water-power stations.

From this comparison it appears that power generated from blast-furnace gases costs about the same as water power, when the capital cost of the generating station, with or without transmission lines as may be required, is about £18 per horse power delivered at the consumers' boundary. In the table giving estimated cost of hydro-electric power stations it will be seen that the majority of plants are estimated to cost more than this figure.

Power from gas engines using blast-furnace gas is, therefore, worthy of more attention than it has received up to the present time in Great Britain. During 1905 the various Scotch blast furnaces turned out 850,000 tons of pig-iron. According to Greiner's rule, with this output the spare power would be about 71,000h.p., on the assumption that the works are equipped with modern gas-blowing engines, &c. If this power were used for the manufacture of calcium carbide, aluminium, or nitrogenous manures from atmospheric nitrogen, it would be possible to get a return of at least £2 per horse power per annum. There is thus an annual loss in the Scotch blast furnaces only of upwards of £140,000. To harness this power the capital cost would be about £750,000, according to the estimate given for the 20,000h.p. station. A return of £2 per horse power per year would give upwards of 18 per cent. on this capital expenditure in addition to the 5 per cent. interest allowed in estimating the cost of the power. There is, therefore, a large future before the blast-furnace gas engine, particularly for the manufacture of artificial nitrogenous manures, of which large quantities will be required in the near future to enable the wheat-growing ground to produce sufficient wheat to satisfy the rapidly increasing number of wheat consumers.

The gas engine using either blast-furnace or producer gas could be adopted with great advantage by public power supply companies and by municipalities where there is a good day-load. Gas engines should be installed of sufficient capacity to deal with the average day-load, and steam plant kept to deal with the peak. With this arrangement the gas engine plant would always be working with a high load-factor and would be able to generate power cheaper than an equivalent steam plant. This combination of steam and gas plant has several advantages and is now receiving the careful consideration of many power supply companies.

APPENDIX.

ESTIMATED CAPITAL COST OF HYDRO-ELECTRIC POWER STATIONS.

Situation.	Power proposed or installed.	Total Cost.	Cost per h.p. installed.	Remarks.
	h.p.	£	£	
Lake Titicaca, Peru..	2,000,000	8,000,000	4 0 0	Scheme outlined by Prof. Guarini, of Lima.
*Mexican Light and Power Company	48,000	417,000	8 14 0	
*Cameron Rapids, Ontario, Canada	16,350	168,300	10 6 0	No transmission costs included.
Augst-Wyhlen, near Rheinfelden, Basle ..	30,000	360,000	12 0 0	Erected jointly by the Basle and Baden authorities.
*Societa Idroelettrica Ligure, Milan	45,500	600,000	13 4 0	
*Aveto River	..	..	14 13 0	Allowing for transmission loss.
Societa Generale Elettrica Adamello, Milan ..	30,000	400,000	13 6 8	Sum given is capital of Co. formed to erect stations in Camonica Valley, Brecia Province. Power transmitted 60 miles to Milan.
Santiago, Chili	20,000	300,000	15 0 0	Proposal of the German Transmarine Electricity Company.
Horahora Rapids, Waihi, New Zealand ..	4,000	70,000	17 10 0	Project of Waihi G.N. Company in return for certain concessions. Part power transmission to Waihi.
*Cameron Rapids, Ontario, Canada	16,350	254,100	17 12 0	Including transmission 75 miles. Power delivered 14,450h.p.
Hauroko	40,000	850,000	21 5 0	From report presented to House of Representatives, New Zealand.
Albula River, near Thusis, for Canton of Zurich, Switzerland	20.000	427,400	21 7 6	Including transmission line 87 miles.
Trollhattan, near Gothenburg, Sweden ..	12,000	275,000	22 18 0	
Gullspang-Munkfors Kraftaktiebolag, Sweden	12,000	281,250	23 8 0	Including transmission lines, &c.
Teviot	25,000	600,000	24 0 0	From report presented to House of Representatives, New Zealand.
Clarence River	25,000	600,000	24 0 0	
Opihi	10,000	250,000	25 0 0	
Huka River	38,000	1,000,000	26 6 0	
	22,000	615,000	28 0 0	
Hutt River	12,000	340,000	28 6 0	
Turin	8,000	231,700	28 19 0	Including transmission line.
Huka River	11,000	325,000	29 12 0	From report presented to House of Representatives, New Zealand.

* Further details of these systems are given in the paper.

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THE CHARACTERISTICS OF TRANSFORMERS.

G. A. BURNHAM.

To understand thoroughly the wiring and connection of constant-potential transformers one should be somewhat familiar with the theory. This necessitates, first of all, an understanding of the following terms: Induced electromotive force, counter electromotive force, impedance, eddy currents, and hysteresis. These will be taken up in the above order and treated rather briefly.

Induced E.M.F.

Let *N* and *S* (Fig. 1) represent the north and south poles, respectively, of a permanent magnet, with the lines of force *ff*, passing from the north to the south pole. *AB* is a conductor to the ends of which are connected two flexible wires from the galvanometer *G*.

Now if the wire *AB* is moved through the field of the magnet, in the direction of the arrow, an e.m.f. will be "induced" or generated in the conductor *AB*, in the direction shown by the arrow-heads, and its presence may be detected by the deflection in the galvanometer *G*. The e.m.f. generated is proportional to the rate of cutting of the lines of force.

Another case of induced e.m.f. which would perhaps relate more closely to the principle involved in the transformer is illustrated in Fig. 2. Let *AB*, as in the previous case, represent a conductor, the ends of which are connected to a circuit containing a battery *E* and key *K*. A second conductor, *AB*, is placed parallel to *AB*, having its ends connected to the galvanometer *G*. Now when current exists in a conductor, a magnetic field is established around the conductor in the form of concentric circles, the planes of which are perpendicular to the axis of the wire in which the current exists, as shown in the engraving.

Now assume the key *K* to be closed and electricity to flow from the battery *E* in the direction indicated by the arrow-heads; as stated above, lines of force will encircle the conductor *AB*. That is, the lines of force will diverge from the centre of the wire and in spreading out will cut the conductor *AB*, generating in it an e.m.f. which produces a current in the galvanometer *G* in the direction of the arrow-heads. It should be noted that the direction of the arrow-heads in the conductor *AB* are opposite to those in *A'B'*, showing that the induced e.m.f. is in a direction opposite to that of the impressed e.m.f.

As it takes time for the current in the circuit to reach a maximum or a constant value, it always takes time for the field to reach a constant value, so that when the current becomes constant, the field is constant, or there is no change in the lines of force, consequently the induced e.m.f. falls to zero—as is true in the case of direct currents.

Counter E.M.F. or E.M.F. of Self-induction.

It was noted above that when a current exists in a conductor as in Fig. 2, lines of force or of magnetic flux are set up around the conductor in a plane perpendicular to the conductor, in the form of concentric rings. (Fig. 3, *a*.) Now suppose, as is the case in Fig. 3, that the conductor *AB* is coiled into several turns. It is evident, from the construction of the coil, that the lines of force from the coil 1 will cut the coil 2, and in the same manner the flux from coil 2 will cut coil 3, and so on throughout the series of convolutions. Thus the coil has been cut by lines of force or flux, and consequently an e.m.f. has been induced in it in a direction opposite to the impressed e.m.f.

A clearer understanding may be had if
the arrow-heads *a* and *b* be allowed to re
sent the counter e.m.f. and the im
e.m.f. respectively, both in direc
intensity. At the instant the
closed the flux tends to become

the
econdary,
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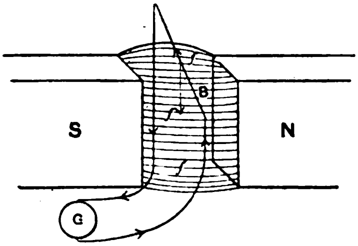


FIG. I.—GENERATION OF E. M. F.

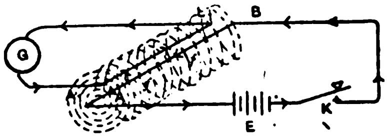


FIG 2.—GENERATION OF E. M. F.

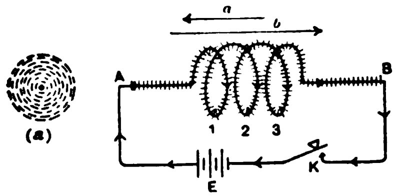


FIG. 3.—PRODUCTION OF COUNTER E. M. F.

when the flux changes less rapidly the counter e.m.f. *a* becomes smaller and smaller until it finally disappears, leaving the e.m.f. *E*, which is the impressed e.m.f. From the above, it is evident that when the flux is constant (as with direct currents) the counter e.m.f. is zero, but with alternating current, where the flux is continually changing, the counter e.m.f. becomes a permanent factor.

One effect of the counter e.m.f. is to retard the current in time-phase with respect to the impressed e.m.f. When a current is started in a wire it does not attain its maximum value instantly, but a certain interval of time is required, just as when one attempts to rotate a heavy flywheel it cannot be made to reach its maximum speed instantly, but time is consumed in overcoming the effects of inertia. In fact, the characteristics of counter e.m.f. of self-induction are practically identical to those of inertia in connection with mechanism.

From the above it may be seen that in addition to the ohmic resistance to oppose the current there is a counter e.m.f. which, although acting in a different manner, attains the same end—that of decreasing the value of the current. The quotient of the counter e.m.f. divided by the current is sometimes called the "reactance." The combined effect of the reactance and the resistance is called "impedance."

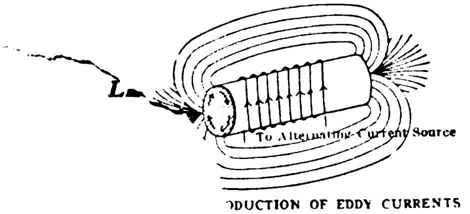
Eddy Currents.

When there is a change in the magnetic flux threading a coil there is an e.m.f. set up in the coil. Now if the changing flux threads through a rod of iron, there will be an e.m.f. set up in the iron itself, as shown by the arrows in Fig. 4. The e.m.f. in the iron acts in a direction to oppose the change in flux producing it.

Now, if in the case of a solid iron core, as in Fig. 4, the resistance of the iron is very small, a comparatively small e.m.f. will produce a considerable value of current. The energy due to this current is dissipated in the form of heat; it can be greatly reduced by properly subdividing the cores. For this reason transformer cores are built up of a large number of thin iron sheets (laminations) insulated from each other.

Hysteresis.

In a piece of iron or steel which is not magnetized, the molecules which constitute the iron lie in every direction with respect to each other. For example, consider a keg of nails to represent the iron bar and let the molecules be represented by the individual nails. Now, as stated above, when the mass of iron is not magnetized the nails point in all conceivable directions, but if a number of turns of wire be placed around the mass of nails and current exists in the wire, the nails would have a tendency to lie parallel to each other and all of them would attempt to point in the same direction. That is, each nail would be a magnet in itself, all of the north poles of the magnets pointing in one direction and all of the south poles in the opposite direction. Each nail may be con-



ODUCTION OF EDDY CURRENTS

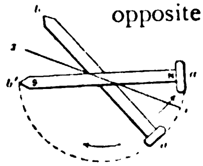


FIG 5—HYSTERESIS LOSS

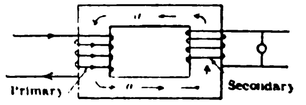


FIG 6—SINGLE-PHASE TRANSFORMER

sidered as having turned on its centre, due to the mutual attraction between the magnetic poles of the adjacent nails or molecules, so to speak. Fig. 5 is a diagram showing the action of each molecule. Suppose that the nail in the position *a′ b′* is acted upon by the magnetism set up by the surrounding coil and that its original position was that indicated by *ab*. Now, if the current is cut off from the coil, the nail will tend to assume its original position *ab*, but will not quite reach it; it will stop perhaps at the line *xy*.

Assume now that the current in the coil is reversed, then the north pole instead of being at *a′* will be at *b′*. It is evident that the nail has been turned from *y* to *b′* instead of from *a* to *b*, as would have been the case had the nail not been magnetized. Thus it appears that the work required to turn the nail or molecule after it has been magnetized is greater than it would have been had the nail not been magnetized. This difference is represented by the arc *ay*, the work being dissipated in the form of heat. The loss of energy is attributed to "hysteresis." This is an exact analogy of what goes on in the molecules of the iron; that is, after the molecules have been magnetized in one direction, and the current cut off from the coil, the whole amount of magnetism does not disappear from the iron, but a small portion remains. This remaining magnetism is called the "residual" magnetism, and in order that the magnetism of the mass of iron be reversed, the residual magnetism must first be neutralized.

Fig. 6 is a sketch of the simple form of a transformer, which consists of a closed magnetic circuit *a* of iron, on which are wound two coils called the primary and the secondary. It is evident from the sketch that there is no electrical connection whatever between these two coils. The primary coil is connected to a source of alternating current, and the secondary coil is connected to the external circuit, which generally comprises lamps or motors.

In order to make the action as clear as possible, consider that the two coils have zero resistance, and also that the reluctance (opposition to the flow of magnetism) of the core is negligible. Consider that an e.m.f. of 2000 volts alternating is applied to the primary of the transformer, which consists of 2000 turns of wire. A negligible value of current in the primary will set up a flux in the iron which will cut the turns of the primary winding, thereby inducing in it a counter e.m.f. of 2000 volts. Assume that the secondary has the same number of turns as the primary, and that there is no magnetic leakage, then the total flux set up by the magnetizing current in the primary cuts the 2000 turns of the secondary, and evidently there will be 2000 volts generated in the secondary coil. If the secondary circuit be closed through a resistance of 400 ohms, a current of five amperes will be produced therein, due to the *secondary* e.m.f. of 2000 volts. The five amperes of secondary current will tend to demagnetize the core, and an equal counter magnetizing current of five amperes will flow in the primary. Thus the input in watts in the primary will equal the output of the secondary; that is, the number of watts in the primary is 5 amp. × 2000 volts = 10,000 watts, which is the same as in the secondary. In the above case the number of turns in the primary and secondary were equal, and the secondary voltage and current were equal to the primary voltage and current. Assume now that the secondary consists of 200 turns; in this case only one-fifth of the number of turns which constitute the primary is cut by the core flux; consequently, only one-fifth of the voltage will be induced, namely 200 volts between the secondary terminals, because the e.m.f. is directly proportional to the number of turns of wire—the flux being the same as formerly. If now the resistance of the secondary and circuit be reduced to four ohms, its secondary current will be 50 amperes (due to the secondary e.m.f. of 200 volts) and the secondary power will be 10,000 watts. Fifty secondary amperes in 200 turns will require five amperes of counter magnetizing current in the 2000 primary turns. Thus, although the e.m.f. was reduced from 2000 to 200 volts, at the same time the current has increased from 5 to 50 amperes; a reduction in the voltage of 10 to 1 and an increase in the current of 1 to 10; these factors are called the "ratio of transformation."

The ratio of the voltage in the primary and the secondary depends entirely upon the relative number of turns in the primary and the secondary coils, and by dividing the e.m.f. of the primary by that of the secondary, the ratio of transformation may be obtained.

In the above example we have a case where neither eddy current nor hysteresis in the core, no loss due to ohmic resistance of the copper, and no magnetic leakage reactance in the coils has been considered; these all play an important part in the commercial transformer. The efficiency is reduced from the ideal 100 per cent. to from 96 to 98 per cent. in transformers of from 50 to 75 kw.—*Elec. World.*

Thermo-electric Tests of Silicon.

An investigation of the thermo-electric behaviour of silicon in the metallic state has been made by Frances G. Wick, the results being published in *The Physical Review* of November last. One of the first difficulties encountered was that of securing a good electrical contact. The best results were obtained by copper plating the ends of the silicon rod first, then placing the connecting wires on the copper and plating over them. This connection, however, was not entirely satisfactory as the copper plating did not adhere firmly to the silicon. Copper and constantan wires were attached to each end of the silicon and the thermo-electromotive forces were measured at different temperatures, and with various differences in temperature between the ends. The different thermo-couples formed by the copper, constantan and silicon served to check the measurements. The temperatures ranged from – 190deg. Centigrade to 350 deg., while one end of the silicon was kept as near zero as possible. The conductivity of the silicon for heat gave some trouble in this experiment. The direction of the current was found to be from the silicon to the copper through the hot junction. Hence silicon is thermo-electrically negative with respect to copper. From these results the thermo-electromotive force curve of a silicon-lead junction was computed and plotted. The values were found to be high and the curve to be at least of the third degree, possibly due to a large Thomson effect. The line for the copper-silicon couple is also slightly curved. The large values of these thermal electromotive forces are shown by the following comparison: At the mean temperature of 20degs. Centigrade the thermo-electric power of a lead-silicon couple is – 400 microvolts per degree. Under the same conditions a bismuth-lead couple gives – 89 microvolts, and an antimony-lead couple + 26. Tellurium and selenium are comparable with silicon, but of opposite sign. The first gives, with lead, + 502, and the second, + 807 microvolts.

Electric Heating.

The following abstract of a report presented to the Association of Edison Illuminating Companies, U.S.A., at their convention in September last, will be read with interest by central station men in this country. The committee making the report included prominent electrical supply men of New York, Brooklyn, Boston, and Chicago.

The committee on electric heating concluded that the members were more generally interested in the commercial progress of electrical heating apparatus than in any other features, and consequently did not introduce any results of economy tests or information of that character. General information was obtained from the member companies through the medium of question lists sent out. Seventy-five sets of questions were sent out and replies were received to fifty-seven.

Question 1. What is your company doing in the matter of exploiting electric heating and cooking devices?

Forty-seven companies were more or less enthusiastic and are doing what they can in a variety of ways to promote the sale and use of heating apparatus. Twenty-four are both advertising and demonstrating its use; eleven are demonstrating alone and five advertising alone; twenty-five employ special canvassers, and seven put out apparatus on trial. A great majority of the replies emphasize the desirability of suitable display rooms.

Question 2. Have you conducted a campaign on any particular piece or pieces of apparatus? If so please advise the committee as to particulars and results.

Forty-four have conducted iron campaigns, which seem to have been in most cases successful, the general plan having been to deliver the irons at the houses of customers for trial, covering periods ranging from five to thirty days. The information is not sufficiently complete to give any average figures as to the number of irons which should be placed in a given community per 1000 inhabitants, but several report the number of irons placed over 1000, and the results of these campaigns seem to have been generally satisfactory to the companies.

Question 3. What do you estimate the

annual kilowatt-hour consumption of the following pieces of apparatus in the average household? (For instance, one company reports that it finds that a flat-iron in the average house consumes 6 kw.-hours per month). Flat-iron, chafing dish, percolator, heating disc, radiator, water-cup.

Twenty-seven answered as to flat-irons, and of this number 80 per cent. placed the annual consumption between 60 and 84kw.-hours, an average of slightly over 72kw.-hours per year. Fourteen answered as to the percolator, but the estimates varied materially, 50 per cent. placing the annual consumption at between 50 and 90kw.-hours per year, with an average of about 65, which would be a fair average of all answers. The answers regarding other pieces were so meagre as not to give any very satisfactory information, with the possible exception of the radiator, on which the estimates ran from 300 to 400kw.-hours per year. One company reported results of the use of an experimental electric kitchen with which all the meals for three grown people were prepared. This showed an average consumption of 195kw.-hours per month. Another reports the cooking bill of a family of three at $4.50 (18s. 9d.) per month, and a family of five at $7 (29s. 2d.) per month average, the electricity being charged for at 5 cents (2½d.) per kw.-hour.

Question 4. Do you employ special canvassers in the sale and exploitation of this kind of apparatus, and if so, are they men or women, and on what basis and how much do you pay them?

Twenty-five companies employ special canvassers for the sale and exploitation of heating apparatus, a considerable percentage employing women for this purpose. Some of the reports as to wages paid indicate an average of from $55 to $80 (£11 to £16) per month for the men, some paying straight salary and others combined salary and commission. Eight companies reporting on the salaries of women pay from $9 to $16 per week, the average being apparently $11 or $12 (45s. or 50s.).

Question 5. Are you of the opinion that the sales of heating apparatus from all sources have increased in your territory during the past year?

Thirty-eight answered "yes," many of them indicating that the increase is very considerable. Nine report not much, if any, increase, and the balance fail to answer.

Question 6. Have any special methods of building up good business in the heating field come to your attention?

In answer to this question we have the following:

Demonstration at the company's office.

Demonstration at customer's residence.

Special canvassers.

Sale of apparatus at cost and on the hire-purchase plan.

Free trial.

Advertising.

Special rates.

As premiums for newspaper subscriptions.

Interest architects, builders, and the company's agents.

Question 7. Have you any theories as to how this business may be developed?

The answers to this question bring out no other suggestions than those indicated by the answers to Question 6.

Question 8. Have any instances of fires being started by this kind of apparatus come to your attention, and if so, please give details?

A very considerable number of companies appear to have had experience with fires started by heating apparatus, but the majority of these cases seem to have been the result of careless use. This, however, may argue that the manufacturing companies should pay more attention to the development of automatic devices for shutting off the current. A number of fires were caused by bed covers being ignited from heating pads, the inference being that defective connections were responsible. Thirteen companies report specific instances of fires.

Question 9. Are you taking any steps in the way of running special circuits in new buildings or advising that they be run, or in advertising to architects and builders the desirability of providing separate circuits for heating devices, looking in a general way to procuring this class of business in future on power or special rates?

Eighteen companies reported advertising to architects and builders; eighteen others are doing absolutely nothing; nine fail to answer; and only a few are making slight efforts to educate the public in this manner.

Question 10. Please give briefly any information on this subject not brought out by these questions which you think will be of interest to the association through this report.

There were many interesting bits of information brought out under this question, but few which throw any great amount of light on the subject. One company reported information obtained from one dozen kitchen outfits, each doing the entire household cooking where it was installed, which showed the average cost was between \$1.50 (6s. 3d.) and \$2 (8s. 4d.) per month per person, at a rate of 5 cents (2½d.) per kw.-hour.

In general the answers to these questions indicate that there has been substantial progress made in the introduction of this class of apparatus during the last two years; that while the flat-iron is still the favourite, other apparatus is selling well; that women canvassers are very successful in introducing the apparatus, and that with proper pushing a great deal can be put out from which a handsome income can be obtained, without making special rates. The replies of several companies would indicate that vigorous exploiting of this apparatus for two or three years should easily result in the sale of from ½ to 1kw. of energy per annum per inhabitant at the regular retail rates.

Inspection of Conduit Installations.

D. McKELLIN.

WHEN inspecting conduit work that is being installed, it is well to look out for the following points:—

The duct for feeders should be large enough to pull a wire at least two sizes larger than what is immediately necessary, so as to provide for future increase in number of lights, small motors, &c.

Should have no small bends, so that there will be no excuse for faking the size of feeders or the thickness of insulation or using grease or oil when pulling in.

Should not be run too close to great heat such as boiler or steam pipes, as such proximity will cause the insulating compound to run and stick to the inside of the duct, causing difficulty should it ever be necessary to pull it out, and deteriorating the rubber of the insulation.

Should be so run that there will be no vibration communicated to the duct, as this will in time cause it to break at the threads and admit moisture, or one broken end may hang on the wires in such a way that if a leak should occur it would burn away enough of the conduit to allow flame to be communicated to surrounding material. Also for the same reason the supports on hanging duct should be close together and so arranged that each will support its share of the duct and not leave the weight on a few supports and the remainder hanging loosely if not actually adding weight or strain to those that are tight.

It often occurs in cutting long threads on any kind of conduit that the die will start crooked and by the time it reaches the limit of the cut one side will have cut down into the duct so far as to cause a leak or force a sliver of steel through so that it is bent down inside of the conduit in position to possibly tear the insulation.

It should be seen that all conduits enclosing wires which are carrying large currents are extra well earthed so as to blow a fuse in case of accidental earth rather than melt up a lot of steel and copper by not having a return circuit of low enough resistance. In this regard it is well to remember that conduit threads rust as time goes on and that if there are only a few threads in contact with the coupling the resistance will become greater than if exactly half of the coupling is in contact with each length of conduit, and that if the thread is loose in the coupling it will rust much quicker and to a greater extent than if good and tight. This is most likely to occur in running threads, therefore they should be well backed up by locknuts and should be seldom used in the large sizes of conduit.

The return circuit in case of accidental ground will be much better if the thread on the conduit is well cleaned with the die before being screwed together.

The reaming of conduits is a matter that should be watched carefully. If not reamed enough, it will scratch or tear the braid and be difficult to pull in. If reamed too thin, the ragged thread at the end is likely to turn down into the duct when forced up hard against the end it meets in the coupling, thus making matters even worse.

Another matter which is sometimes not given sufficient attention is the bonding together of ducts at the boxes. Ordinarily the locknut and bushing is depended upon entirely for continuity of the return circuit, and this is very poor dependence, as it seldom is tight enough to amount to much as a current-carrying medium, and when it is forced up tight the contact is made on the enamel of the box in most cases. The contact thus obtained is usually enough to blow a 6 amp. fuse, but will give poor results on one of 300 or 400 ampere capacity.

A careful inspection of the bushings on all sizes of duct to see if they are good and not likely to come off readily is one of the duties of the inspector. The size of the cut-out boxes is an important item, because a box that is small will necessitate bad arrangement of the wires in order to accommodate enough cut-outs and switches.

Many wiremen use grease, oil, soap, or any lubricant that comes handy to facilitate pulling in on long runs or runs of large wire, and the best grease does some harm to the insulation, while some kinds are exceptionally bad. Therefore it is necessary for the careful inspector to look for indications of its use.

Powdered plumbago or soapstone will never harm good insulation, so are permissible, and are perhaps the only kinds of lubricants that should be allowed.

Sometimes when the architect or consulting engineer has an inspector of his own on the job, the regular insurance or public supply official relies considerably on his supervision and does not visit the job as frequently as he otherwise would. Such a practice makes things easy for the mechanic who wants to slip something over, because ninety-nine times out of a hundred the electrical engineer or architect is simply a laughing stock for the practical men by insisting on things that are of absolutely no moment whatever and allowing the rottenest kind of work to go in right under his eyes.

Occasionally a firm of consulting engineers have a practical man with them, but it is very seldom, owing to the fact that college educated electricians can be hired so much cheaper than the practical man who really knows his business.

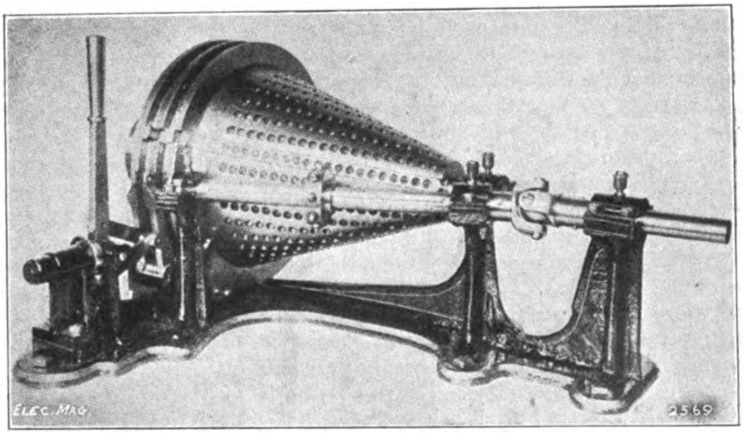
The inspector should try to be on the job when the pulling in is being done, if possible. In fact, the contractor should be obliged to notify him regarding the time when he will have his men at that branch of the work, because that is the time when even the fairly decent contractor will sometimes consent to a piece of "funny" work rather than tear out plaster or rip up flooring to make the job secure.

Many a smart trick is played on switch box covers at this time, too, where they have been installed out of plumb. Sometimes when too many taps have been run to the switch box, or an end of one of the ducts projects too far in, a clever workman will break off a part of the porcelain of the switch to make it fit.

If the longest of the circuits have been pulled in in the absence of the inspector, he will sometimes gain considerable information by having a couple of them pulled out for examination.—*Electrocraft.*

A New Variable-Speed Gear.

THE illustration below shows a new form of variable-speed driving gear recently placed on the market by a New York firm. The device will be found of particular service for deriving variable speeds from a constant-speed electric motor. Based fundamentally on the cone-and-gear principle, it utilises this principle in a new and very ingenious way. As will be seen, the "gear cone" is provided with a number of circumferential rows of "gear pits," and parallel with the side of the cone is a shaft on which



A New Form of Variable Speed Gearing.

is feathered a spur gear having pin teeth of a general conoidal form. This gear is adjustable longitudinally on its shaft so as to be brought into mesh with any desired row of gear pits on the cone.

From mathematical considerations, deducible from the geometric properties of a cone, if the number of pits in the successive rows differ in arithmetical progression the rows themselves must be equidistant from each other. For example, if the row nearest the apex has eleven pits, the next twelve, the next thirteen, and so on, the distance from the first to the second, from the second to the third, and so on, is the same. Hence the gear can be shifted by equal steps from either end of the cone to the other and be in mesh with a row of pits at each step. Furthermore, the rows can be so arranged that one pit of each row will lie in (or strictly speaking, will be bisected by) the same axial plane.

From the illustration it will be noticed that there is a straight or longitudinal series of pits formed on a sliding bar in the cone side capable of movement in both directions a distance equal to the space between successive circular rows of pits. At the instant in the cone's rotation when the slide is parallel with the gear or pinion shaft, if the slide is shifted it will carry the pinion to the next row of pits.

At the base of the cone are two grooves, which the slide crosses, and projecting from the slide into the grooves are two studs, the arrangement and proportioning of the parts being such that the studs, when the slide is in its normal position, are spaced slightly from the rib between the grooves.

Adjacent to the grooves are two oppositely inclined cams, each equal in width to the distance which the slide must move to transfer the pinion from one row of pits to the next, so that the cams, engaging the stud on the slide, will shift the slide the proper distance.

The cams are mounted on the upper ends of two arms pivoted at their lower ends. For the purpose of actuating the arms they are connected by links to a controlling lever on opposite sides of the pivot of the latter. This method of connecting the cam arms with the controller makes it impossible to throw both cams into the grooves at once. Normally, both cams are retracted to the inoperative position, and to produce this retraction instantly when the operator releases the controller a spring-pressed plunger, having a flat face, bears against the controller on both sides of its pivot. Hence oscillation of the controller in either direction will compress the plunger spring, which will, on release of the lever, throw the lever immediately to its inoperative position, with both cams retracted from their respective grooves.

To restore the slide to its normal position after each actuation, an inclined member is provided at each side of the flanges at the base of the cone, against one or the other of which one of the side lugs strikes after passing the gear. Thus if the slide has been moved toward the base of the cone, the end of the slide projecting beyond the flange will engage the adjacent inclined member and will thereby be thrown back to the normal position.

As long as one of the cams is held in its grooves, each revolution of the cone will produce an actuation of the slide and a corresponding shifting of the gear, so that the latter will move step by step up or down the cone, according to which cam is in operation. Arriving at the end of its shaft, the pinion can, of course, go no further in that direction, and the cam must be retracted before the succeeding revolution of the cone brings the slide again into position for actuation.—*Elec. Rev., N. Y.*

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Storage-battery Motor-trucks for Works Transport.

BESET by the problem common to all large industrial establishments of transporting material from one part of the works to another in an economical manner, the Westinghouse Machine Company of America found the most satisfactory solution in storage-battery motor-trucks of its own design and construction.

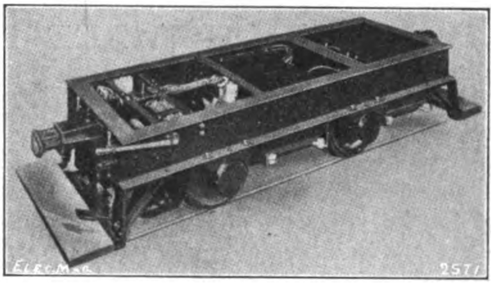
Convinced by the results obtained during several years of continuous service of their fitness for the purpose, the company has put the trucks on the market and is now prepared to furnish them in capacities of from ten tons to 40 tons.

When the storage-battery auto-trucks were installed delays of material in transit were practically done away with, and since the trucks furnished their own power the number of labourers required for moving of material was greatly reduced. More important still, there was a marked improvement in crane service, since a crane was no longer needed for transporting castings below 10 tons in weight (the first trucks installed being of 10 tons capacity) from one end of the long shops to the other, often driving several cranes before it and putting them temporarily out of commission.

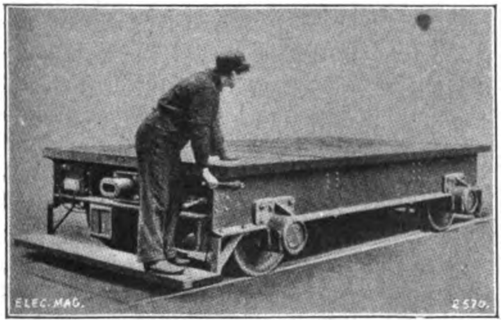
The trucks, though of extremely simple construction, are substantially made of the best materials. A steel frame, thoroughly braced, is carried on four wheels, the journals of which run in roller bearings. The driving axle or axles, as the case may be, carry the motor or motors, as in street-railway practice. A spring-suspended cradle of angle iron carries the battery trays.

At the operating end of the truck are mounted the controller, brake, charging receptacle, cut-out switch and volt-ammeter. A convenient step and draw-bar head are provided at each end. All the machinery is below the top of the frame and is covered by a heavy wooden deck for carrying the load. This deck is made in sections so that any part of the mechanism is readily accessible. The controller gives four speeds and is provided with operating and reverse levers, which are interlocking to prevent premature reversal, thus protecting the motor and the batteries.

The battery is contained in two or more trays of cells and is of ample capacity for the particular service. It is especially designed to operate at high rates of charge and discharge. The time available for charging during working hours is usually thrice the period of time that the truck is actually running. Charging is made so simple that the truck can easily be charged during these idle periods.



Works Motor-truck with cover removed, showing Battery and Controller Gear.



Works Motor-truck complete.

During a six months' test of the standard 10-ton truck illustrated in Figs. 1 and 2 the power required to charge the battery in regular and heavy shop service was accurately measured. It averaged 63 kw.-hours per month. The work done was recorded and averaged practically 700 ton-miles per month, the loads running from a few hundred pounds to 15 tons.

These trucks, used as locomotives on a level track and without any weight to secure adhesion, can haul with suitable trail cars from one-half to their full rated capacity as a truck, depending upon the condition of the track and the kind of bearings on the cars hauled. By placing sufficient weight over the drivers to secure adhesion they are capable of handling from one to two times their capacity as a truck for a continuous period of not more than five minutes.

Standard trucks are made for six different gauges, namely: 18, 21½, 24, 30, and 36in., and 4ft. 8½in. For track systems provided with turntables they are made with rigid trucks. Where tracks are installed with curves the trucks for all gauges up to 36in. are provided with swivelled front axle, permitting free operation on curves as low as 12ft. in radius.

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ELECTRICITY in the IRON and STEEL INDUSTRIES.

Practical Experts are preparing a most Valuable and Exclusive Series of Articles for the Special Iron and Steel Industries Number of "The Electrical Magazine."

—— Publishing April 15th, 1908. ——

A REMARKABLE DYNAMOMETER FOR MOTOR-CAR TESTS.

On the afternoon of Monday, January 6th, an exhibition test of a remarkable dynamometer was made at the clubhouse of the Automobile Club of America, New York. This unique machine determines instantly the speed in miles per hour, the feet per second, the drawbar pull or tractive effort, the horse-power, the grade-climbing ability, and the power of the brakes of any motor-car which is placed upon it. The dynamometer, besides being the most complete apparatus ever built for testing motor-cars, makes it unnecessary to hold speed tests upon the open road, eliminating all danger of road accidents and giving results quickly and accurately.

The accompanying illustrations will give some idea of the magnitude and significance of the apparatus. While, at first sight, it may appear complex, the inter-relations have been so carefully worked out, and the translating and magnifying apparatus so ingeniously connected, that very early in the test even the layman with little technical knowledge can readily understand the functions of the apparatus and appreciate the indications secured.

The dynamometer has a moving track upon which cars can be fully tried while remaining stationary and under observation. In 1904 Dr. Schuyler Skaats Wheeler, first vice-president of the Automobile Club of America, was requested by the club to invent, design and build a machine for determining the performance of cars of all kinds. The present machine is therefore the result of several years' attention to the problem on the part of Dr. Wheeler. It is an assemblage of power absorbing and measuring instruments and a large power chart with automatically operated pointers. It carries the problem of power measurement, integration, and automatic recording of the final results much further than has hitherto been attempted. It absorbs and measures the power so that, at a glance, the speed, tractive effort, and horse-power can be clearly seen and read at each instant. The measurements show the power delivered at the ground by the wheels of the car. This includes every element in the car operation, and therefore shows the net power that is available for driving the car.

Instead of travelling along as on a road, the car is held stationary by cables upon the floor, with its driving wheels resting upon two large drums which reach up through the floor, and which the motor of the car causes to revolve. Fig. 1 is a general view of the indicating and translating apparatus, and Fig. 3 a nearer view of the chart, the traction indicator, the timing motor, and the speed indicator.

Fig. 2 shows the view on the floor below and indicates clearly the relations of the revolving drums and the auxiliary apparatus. Just to the left of one of the revolving drums is a clutch which connects the shaft upon which the drums are keyed to an Alden dynamometer. This form of viscosity dynamometer is well known. Keyed to the same shaft is a 1600lb. pendulum which resists the effort of the drum shaft and registers the amount of pull effected by the motor of the car. The deflections of the pendulum are followed and the pendulum kept from oscillating by means of an oil dash-pot just to the left of the pendulum shaft. On the extreme right of the drum shaft is another coupling which connects up an electrical machine that may be used either as a motor or as a generator for driving the drums or for absorbing power, according to the test under way. Connected directly to the end of the pendulum is a pointer which indicates upon a proper

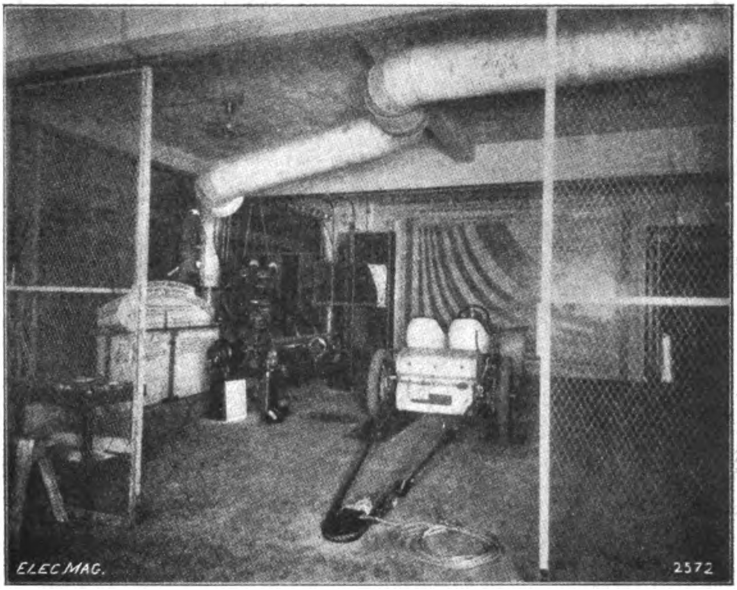

Fig. 1. General View of Motor-car Testing Apparatus. Car in position on Test Floor.

scale the drawbar pull in pounds. This pointer, in its oscillation across the scale, makes contact with an arm on a travelling carriage, which causes contact to be made to either one or the other side of an electrical circuit connected with a traction follower motor. This traction follower motor causes the carriage to be pulled one way or the other, and by means of steel cords the motion is translated to a ruler which forms the vertical bisector on the chart shown in the background of Fig. 3.

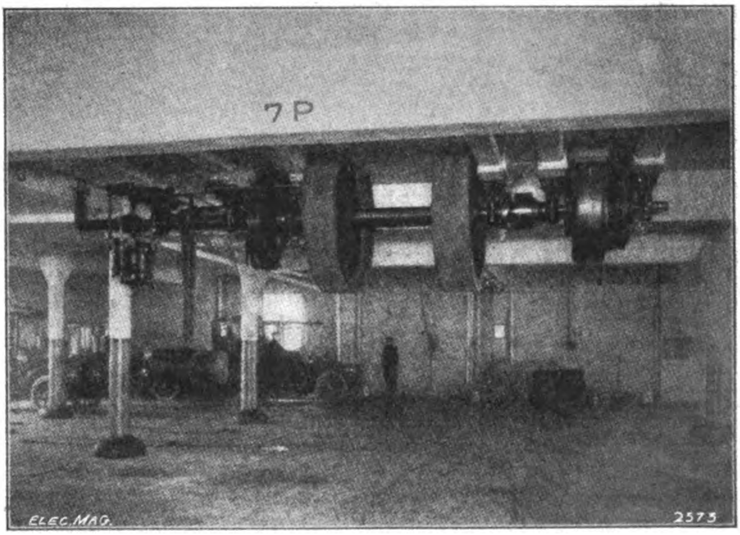

Fig. 2. The Absorption Dynamometer, Speed Indicator Gear, &c., of the Motor-car Testing Apparatus.

For measuring the speed of the car a complicated and ingenious apparatus is made use of. The speed is shown directly by means of a horizontal ruler travelling up and down the face of the chart.

Referring again to Fig. 2, just to the left of the absorption dynamometer, is seen the bevelled-gear connection of a transmission shaft, which is connected directly to the bevelled gears operating a shaft upon which a speed roller is mounted. This apparatus is shown in the foreground of Fig. 3. The timing motor drives a cone at a constant speed of 300 revolutions per minute. To verify this speed, a bell attached to the cone shaft rings at each 100 revolutions or at intervals of thirty seconds. The speed roller driven by the motor car, and, therefore, revolving slowly or swiftly to correspond, rolls upon the surface of the cone and is pulled by a speed follower motor back and forth between the large and small ends of the cone until it finds the point where it does not slip, because that portion of the cone presents the same speed as the roller. This longitudinal adjustment of the roller is transmitted by a wire cable to the speed ruler on the chart, and the power required for

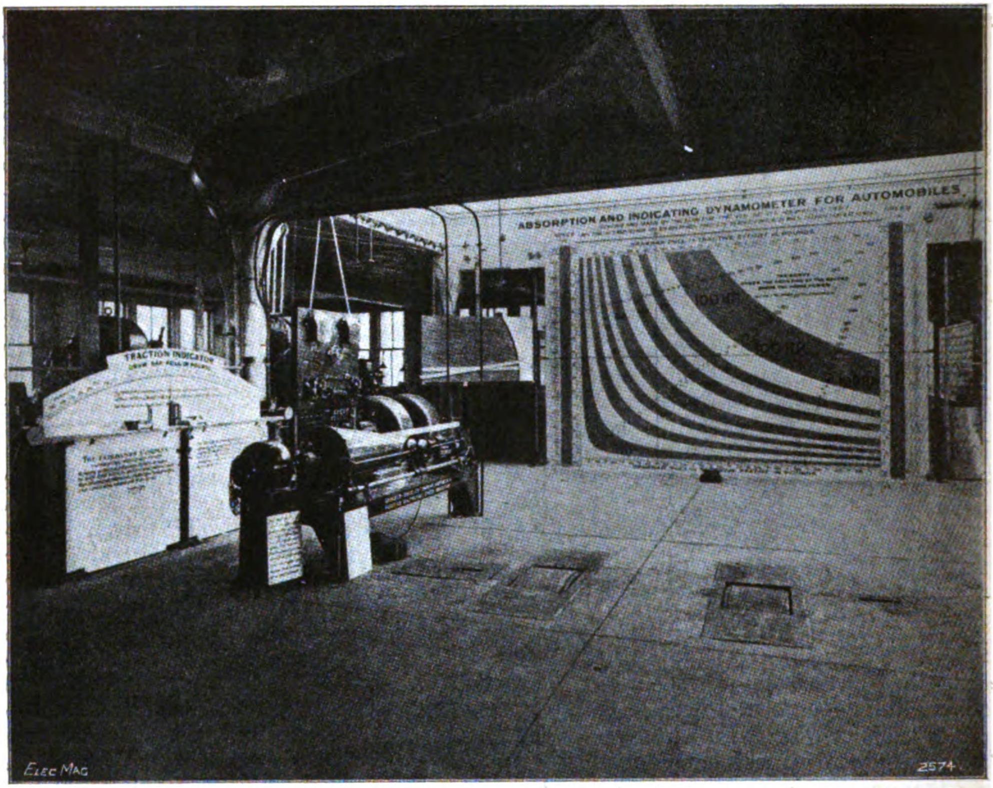

FIG. 3. GENERAL VIEW OF MOTOR-CAR TESTING APPARATUS, SHOWING INDICATOR CHART, &C.

removing the ruler is thus made independent of the car under test. In other words, none of the power of the motor car is used in operating the indicators on the chart. The method of speed measurement employed, based upon one element running at a constant speed, like a clock, that can be verified, ensures great accuracy. The roller driven by the car, if running at sixty miles per hour, must be drawn to a position near the large end of the cone in order to run with the cone; whereas, if the car drives the roller at only five miles per hour, it must be drawn to a position near the small end of the cone. A system of electric contacts is arranged in connection with the speed follower motor to shift the roller automatically until it finds the point where it will roll on the cone without slipping. The speed and power rulers are thus moved across the chart automatically to correspond with the speed and the tractive effort or pull that the dynamometer shows the car is making.

Fig. 3 gives a clear idea of the chart which shows the horse-power corresponding to each different speed and pull, so that the result at each moment can be read at a glance and without calculations. The readings of the chart may be made in miles per hour, minutes per mile, kilometres per hour, &c.

All the measuring apparatus is made reversible so that, when running backwards, the performance of the car may be measured. As a secondary apparatus, a grade meter is provided, operated by the pendulum indicator of the dynamometer. To use the grade meter a clamp is set upon a sliding scale at a point representing the weight of the car. The moving lever then assumes at each moment the angle of inclination of the grade the car would climb (if there were no wind resistance, slipping, &c.) with the effort that the car is then making. The grade meter is shown in the background just to the left of the chart.

To observe a motor car coasting down hill, either forwards or backwards, it is merely necessary to start the electric motor on the shaft carrying the two large drums on which the driving wheels of the motor car rest. The car brakes may then be tested, and the car wheels, or gear, or engine may be run free, and the relative friction loss in the principle of the car may be ascertained.

The apparatus has been constructed by the Crocker-Wheeler Company, Ampere, N.J. The traction follower motor and the speed follower motor are special machines, and the timing motor is a standard Crocker-Wheeler motor. The cone is kept at a constant speed by means of a special design of centrifugal governor. The equipment includes a generator for supplying current to the traction follower motor and the speed follower motor, and a motor-generator set for supplying power to the motor operating the driving rolls or absorbing power from them. A substantial switchboard has also been installed, controlling the main circuits, and equipped with special double-throw switches which are connected according to the conditions of the test. A Weston direct-reading voltmeter and ammeter are used for taking the ampere and volt readings when the motor car is absorbing power, or for making the coasting and running-away tests. The balance weight has been certified by the Fairbanks Company. An induced draft and suction carries off the exhaust from the motor car under test.—*Elec. Rev. N.Y.*

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SINGLE-PHASE TRACTION.

THE NEW HAVEN SYSTEM OF SINGLE-PHASE DISTRIBUTION WITH SPECIAL REFERENCE TO SECTIONALIZATION.*

W. S. MURRAY.

In advance of taking up the concrete subject at hand, doubtless it will be of interest to touch upon several alternative distributing systems that were considered by the engineers of the New Haven railway before the final adoption of the system of single-phase distribution and sectionalization now in service. Some of these were :

1. 11,000-volt, three-phase generation at the power house; transmission along the right-of-way at this voltage; step-down transformers furnishing trolley voltage at 3300; track mileage divided into three equal linear parts, each part being supplied by an individual phase.

2. The same arrangement as (1), with the exception that step-down transformers furnish 6600 volts to trolley.

3. 11,000-volt, three-phase generation at power house; transmission along the right-of-way at this voltage; track mileage divided into two equal linear parts, each part having its trolley connected through the transmission line to one of the three terminals of the power house bus-bars, the remaining bus-bar being connected to the tracks, thus making a common connection for the two trolley sections. The three diagrams of Fig. 1 represent respectively in the simplest form the three above-described arrangements. It follows, of course, that the phased divisions in each case could be further individually subdivided into sections wherever desirable. The presentation of these three methods of distribution by no means prescribes the limit of combinations that may exist, as many others of an interesting character have been suggested.

4. 11,000-volt, three-phase generation, transmission along the right-of-way at this voltage, only one phase being applied to all sectionalized trolley wires throughout the

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* Abstract of Paper read before the American Institute of Electrical Engineers, New York, January 10th, 1908.

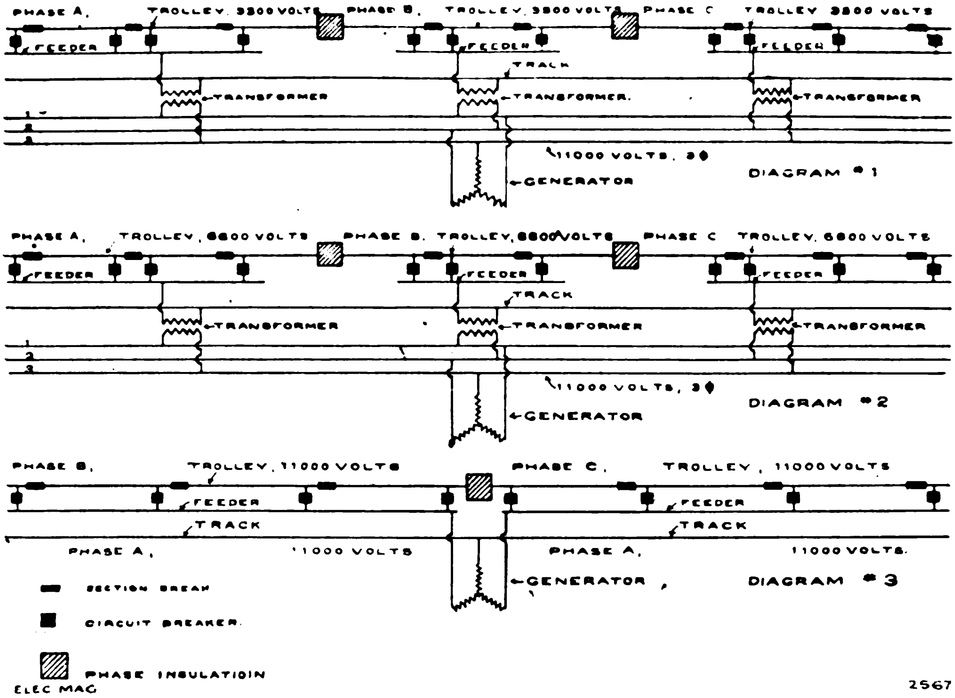


FIG. 1.

zone of electrification. The three phases are also carried throughout the electrification zone, and are at all points available for polyphase motors, such as would be used in railway machine shops and for the operation of motor-driven generators in local direct-current railway plants owned by the railroad company.

In Fig. 2 there is shown diagrammatically the actual scheme of single-phase distribution which has been adopted, and is now in service.

There are advantages to be gained in any one of the above-mentioned alternatives, but the single-phase distribution as described under 4 carries with it advantages, the sum of which far outweighs the sum of the advantages in the others. In a word, the distribution as described under 1, 2, and 3 would seem to offer a better opportunity to distribute the load in the three-phase windings of the generators, and yet this is open to question on account of the possible unequal distribution of trains in the individual phased sections; but the greatest and deciding disadvantage to any of the three-phase distribution schemes is the complication that results in the overhead system, together with the fact that for an equal weight of overhead copper the efficiency of the single-phase system is higher than any of the polyphase arrangements. From the foregoing, the author believed it would be generally conceded that the single-phase scheme of distribution is the best.

A modification of arrangement 4, which was considered, may be mentioned; namely, 11,000-volt, three-phase generation, single-phase distribution for traction with step-down transformers distributed along the line, their secondaries furnishing 3300 or 6600 volts to the sectionalized trolleys. For the reason that the life-hazard in using 11,000 volts was not considered to be greatly increased over that of 3300 or 6600 volts, and in view of the higher efficiency, lesser currents to be collected by locomotive shoe contacts, greater reliability, and the lower operating costs (no transformer sub-stations), the advantages of the 11,000-volt direct transmission to the sectionalized trolleys was immediately apparent, and the problem became simply one of insulation.

As concerns the choice of three-phase generators in connection with single-phase distribution for traction purposes, again local conditions were the real factors that framed this conclusion. Single-phase or balanced polyphase voltages are undeniably more desirable than unbalanced ones; at the same time when proper allowance and arrangement are made for the unbalanced voltages, and there is a decided market for polyphase power, it is difficult to escape the conclusion that it is a desirable and necessary adjunct to the system. In connection with its application to the New Haven electrification, it may be said that synchronous motors will be substituted shortly for steam engines in one of the lighting plants. Such arrangements will bring about the centralization of power generation, and by proper field adjustment of the synchronous motors the general power-factor of the single-phase system will be raised.

Having touched upon some of the determining factors that brought about the arrangement of three-phase generation and single-phase distribution, the remainder of this paper will be confined to a discussion of the methods and lengths involved in the sectionalizing of the single-phase distribution, and as the power wire (which is the outside wire marked *P* in Fig. 2) plays only an unimportant part in its applications to the traction system, it will not be referred to again.

Single-phase distribution offers an excellent opportunity for sectionalizing. As may be seen in Fig. 2, the system consists simply of the track trolleys, two auxiliary wires immediately adjacent, and the necessary switching complement. Although these auxiliary wires have been called feeder wires, and while, as a matter of fact, they do serve to increase the capacity of the overhead system, this is not their principal function, as the amount of copper included in the trolleys would suffice to be within the economic figures of copper loss. The auxiliary wires are installed to serve as by-passes, in the event of it being desired to cut dead any or all of the trolley wires in any section. Thus by this system of auxiliary by-passes any degree of sectionalizing can be used, and any or all trolley voltages in sections can be removed without interrupting the continuity of the voltages throughout the zone.

The lengths of sections are governed entirely by local conditions. No two sections of the fourteen that exist in the twenty-one miles of New Haven electrification are the same. It is seen, however, from these figures, that the average length of sections is 1.68 miles, that none of these is over 2.19 miles or less than 1.07 miles.

The best reason that can be assigned for the use of sections is in order that line troubles may be localized. There are many others, and some of a most important character. Indeed, it may be said that were the line absolutely immune from trouble, such as grounding, mechanical failures, &c., there would still be many good reasons for sectionalizing it, and these reasons will develop as the subject is further studied.

One of the most attractive features of single-phase distribution is the elimination of sub-stations with their fixed and operating charges, and unlike the alternating-current-direct-current scheme of distribution, where the length of section is settled by the equation of load and copper to meet it, the single-phase system is not bound by these limiting electrical conditions. Line-loss is forgotten in the establishment of a mechanical construction, the amount of copper in which is only a fraction of the amount required for an equivalent loss for same amount of power transmitted in the alternating-current-direct-current systems. This convenience of transmission with low loss permits sectionalizing *ad libitum*, and the local conditions are accorded almost the entire privilege of decision. The advantage of such a relation between operation and distribution was immediately apparent to Mr. E. H. McHenry, vice-president of the New York, New Haven, and Hartford Railroad Company, whose suggestion that the electrical and train signal blocks be made co-terminous was adopted. It will be noted, then, that of the fourteen electrical sections between Woodlawn and Stamford, nine of these are co-terminous with the signal towers. In each of these towers there is installed a small panel containing the pilot-switches controlling the trolley (and by-pass) circuit-breakers installed on the anchor bridges. Aside from the economical features of this scheme of control, as no operators other than the present signal operators are required, the value of placing the distribution in the hands of this class of men is most important, their constant attention to matters pertaining to the operation of trains bringing about the attention which should be accorded to the distribution of current; their thorough understanding of

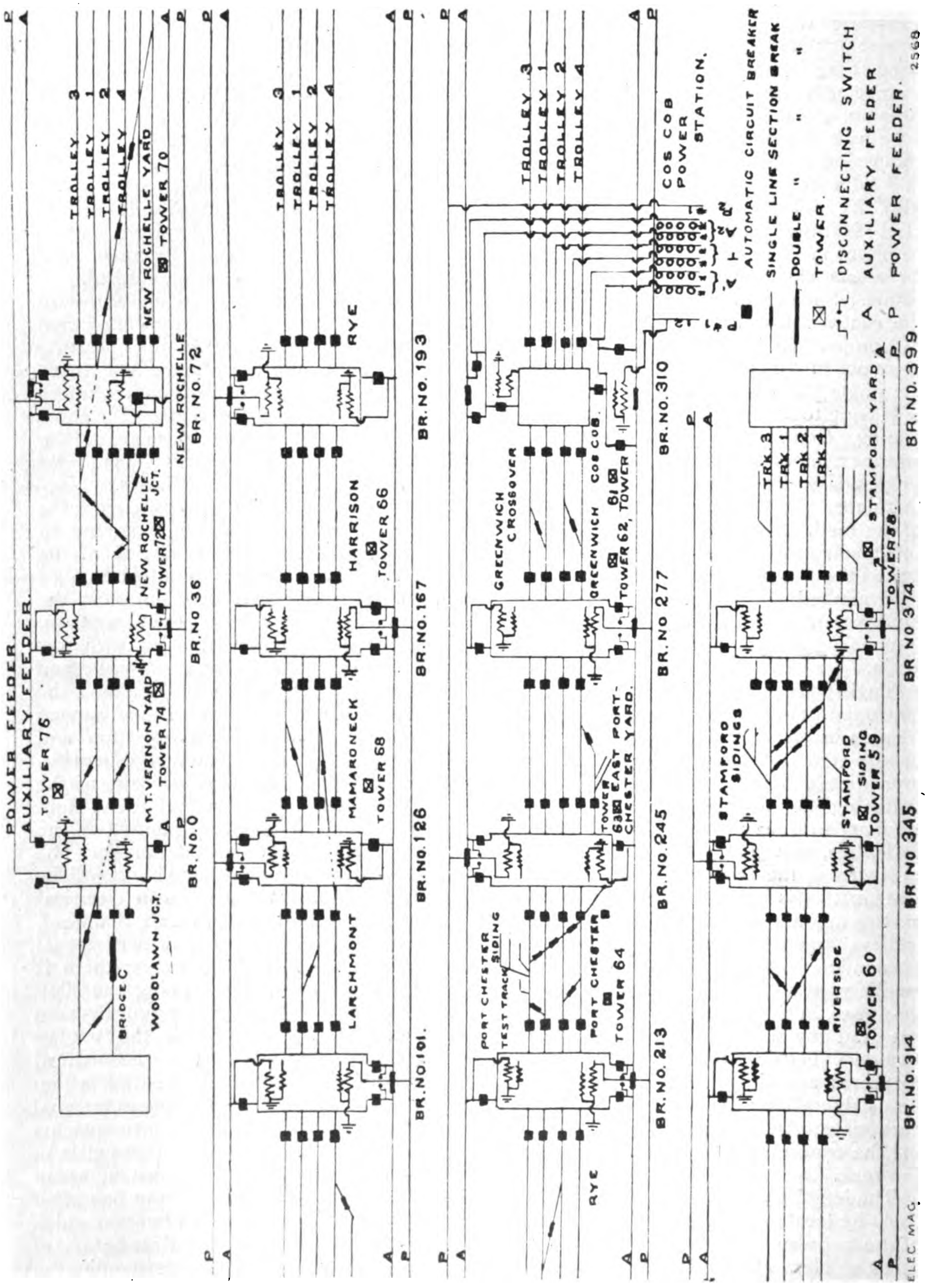

POWER FEEDER.
AUXILIARY FEEDER.
P
A
TOWER 76
BRIDGE C
WOODLAWN JCT.
MT. VERNON YARD
TOWER 74
NEW ROCHELLE JCT.
TOWER 72
NEW ROCHELLE YARD
TOWER 70
TROLLEY 3
TROLLEY 1
TROLLEY 2
TROLLEY 4
BR. NO. 0
BR. NO 36
NEW ROCHELLE
BR. NO. 72
LARCHMONT
MAMARONECK
TOWER 68
HARRISON
TOWER 66
RYE
TROLLEY 3
TROLLEY 1
TROLLEY 2
TROLLEY 4
BR. NO. 101.
BR. NO. 126
BR. NO. 167
BR. NO. 193
RYE
PORT CHESTER TEST TRACK
PORT CHESTER SIDING
PORT CHESTER
TOWER 64
TOWER 63 EAST PORT-CHESTER YARD.
GREENWICH CROSSOVER
GREENWICH
TOWER 62, TOWER 61
COS COB
TROLLEY 3
TROLLEY 1
TROLLEY 2
TROLLEY 4
COS COB POWER STATION.
BR. NO. 213
BR. NO. 245
BR. NO 277
BR. NO. 310
RIVERSIDE
TOWER 60
STAMFORD SIDINGS
STAMFORD SIDING
TOWER 59
TOWER 58
STAMFORD YARD
TR'K 3
TR'K 1
TR'K 2
TR'K 4
BR. NO. 314
BR NO 345
BR NO 374
BR. NO. 399
AUTOMATIC CIRCUIT BREAKER
SINGLE LINE SECTION BREAK
DOUBLE " "
TOWER.
DISCONNECTING SWITCH
A AUXILIARY FEEDER
P POWER FEEDER.
ELEC. MAG.
2568

Fig. 2.

the conditions of traffic on the various tracks permitting the most intelligent handling of electrified and de-electrified trolleys, assuring at once prompt and reliable service in the matter of handling a situation when cross-overs have to be made on electrified tracks, and while repairs are being made on others from which the voltage has been removed. The value of placing the distribution system in the hands of the signal operators may be again illustrated by saying that should an electric train run past a stop-signal set by the operator, or should the operator desire to stop a train in his block, he has only to trip the pilot-switch controlling the trolley circuit-breaker, from which the train is drawing its power, and signal the operator in the adjacent tower to do likewise. The individual value of this protective perquisite is an illustration of the use of sectionalizing outside of the question of line troubles.

As before stated, it is impossible to select some standard distance for sectionalizing the line and then apply it to a steam road undergoing electrification. It is possible to conceive of an entirely new electric line subjected to this hypothetical course of procedure, but even in this extreme case it is difficult to escape the exceptions that could be taken to it; for example, what a strange coincidence it would be to find fifty towns just two miles apart along a railway's right-of-way. On the other hand, how important each town would be whereat to locate a signal tower with its complement of electrical equipment.

In the discussion of sectionalization it would seem proper, therefore, instead of specifying the length of sections, to specify the number to be used over a given total distance; their individual length varying in accordance with the local conditions peculiarly related to them. Upon this basis it will be interesting to enumerate the following advantages and disadvantages peculiar to a choice of a "small number" and a "large number" of sections over a given distance. In this table it should be remembered that usually the items of advantage for the "small number" of sections will be items of disadvantage for the "larger number," and *vice versâ*. Also it is assumed that the signal towers along the right-of-way average about one and a half miles apart and that electrical sections of this length or longer will be classed as a "small number," and sections shorter than this will be classed as a "large number."

A tabulation of the advantages and disadvantages of the use of a "small number" against a "large number" of sections is as follows:—

SMALL NUMBER.

Advantages.	*Disadvantages.*
1 Co-terminous tower scheme more easily arranged.	1 Difficulty of locating grounds increased.
2 Less switches to maintain.	2 Greater section of track cut dead in case of ground or other trouble. Disadvantage, however, related to cross-overs.
3 More reliable; due to less frequent grounding of line.	3 Larger section breakers required.
4 Less cost.	

In advance of a discussion of the items in the above table, it is fair to assume that convenience of construction of the apparatus required for either the long or short sections may be equated. That is to say, the work-train service in either case would be about the same, and the structures to be put up of a character which would require much the same general superintendence and engineering.

In the case of the long sections, it would, of course, be necessary to splice the messenger cables, as they could hardly be manufactured on single reels greater than two miles in length, but the splicing process would not be a matter of great inconvenience, and would not detract from the value of the cables.

On the other hand, in the case of the shorter sections a greater number of anchor bridges would be required for the supply of sectionalizing switches, but this form of structure would not increase to any extent the difficulties of erection, nor would the placing of apparatus upon them interfere with regular traffic.

Taking up the discussion of the above tabulation of advantages and disadvantages for the small number of sections *versus* the larger number; or, stated in another way, sections of greater length *versus* sections of shorter length, we note that under "advantages":—

1. *Co-terminous tower scheme more easily arranged.* This is the most important factor favouring a small number of sections. It is quite clear that with a great number of sections, their termini would fall at points

between towers, necessitating some form of sub-station or building for the electrical operators. This would be inconvenient, both for the railway company and the operator, on account of the cost of maintenance and operation for the former, while the latter would be far removed from his living point.

The reason that the co-terminous scheme is more readily arranged with the use of long sections is apparent, in view of the fact that no convention is necessary to be followed in regard to standard distances, it being at the option of the engineer to choose such towers as are already located on the line as the termini of electrical blocks.

2. *Less switches to maintain.* This advantage is immediately seen, in view of the number of switches being directly proportional to the number of sections, and there is general agreement that a switch in any line does not increase the reliability of that line.

3. *More reliable; due to less frequent grounding of line.* At the present stage of the art, the anchor insulators, which have given the best results from a combined mechanical and electrical strain point of view, have been of corrugated cylindrical form. In this form their insulating value is unquestionably less than the mushroom or petticoat type of insulator, and experience indicates that they are very much less reliable than the mushroom or petticoat type (this form of insulator is used to support the messenger cables on intermediate catenary bridges). It is believed, however, that by suspending some form of protective shield or petticoat from the anchor insulator its insulating value will be greatly enhanced. The blast from steam locomotives seems to produce a very rough enamel of coal dust and cinders, which, on account of deeply imbedding itself in the insulator, it is almost impossible to remove, in consequence of which insulating values are greatly reduced.

4. *Less cost.* It is immediately apparent that the cost would be much less on account of the elimination of a larger amount of switching apparatus and the heavy bridge work required at all anchorages.

In the table of "disadvantages" are to be noted :—

1. *Difficulty of locating grounds increased.* This is quite apparent in view of the fact that there are a greater number of insulators between the circuit-breakers, but experience in actual operation has indicated that this is not a serious matter, as the offending insulators are very quickly located, and there is also being perfected at this time a resistance scheme of measurement by which the point of earth can be approximated within 5 per cent. of its actual position; and upon the perfection of this apparatus this difficulty will be eliminated.

2. *Greater section of track cut dead in case of ground or other trouble; disadvantage, however, related to cross-overs.* This trouble would be of a more serious character if it were railway practice to include a great many cross-overs on the main line. The average distance between cross-overs on the New Haven road is even greater than the distance of the electrical blocks; in consequence of this, should a section become dead on account of a ground, it is possible that the train would have to cross over at a distance from the trouble greater than the length of the electrical section. Railway engineers look upon cross-overs as a necessary evil (remembering their high cost of maintenance, together with the necessity of interlocking machines in conjunction with them), and it is fair to assume that their distance apart will not be decreased for the convenience of shortening the electrical sections; hence, this difficulty cannot be classed as one of special moment.

3. *Larger section breakers required.* In the use of longer sections, it is apparent that more trains may be drawing power from the section breakers, in consequence of which it is necessary to design them for greater capacity and they will be called upon to open larger propulsion currents. The difficulty of this, however, fades in the maximum demand upon the breakers being a short circuit, and as this is a duty a section breaker of any capacity has to stand ready to perform, this objection might be considered as not existing.

It would be a strange state of affairs if it were impossible to improve upon any principle or form of construction adopted. In regard to principles which have governed in the electrification and sectionalization as adopted by the New Haven railway. Careful inquiry into the opinion of those who are responsible for the operation of the electric trains and the distribution of currents to them shows that if any change were to be made, possibly some advantages would accrue in the use of a longer section.

In regard to form of construction. It is fair to say that there are many changes that can be and are being made which will greatly increase the efficacy of distribution. The New Haven electrification has been looked upon as a radical departure from engineering practice. There is no question about the justice of such a remark when viewing the matter as a whole. If, however, we segregate each link in the chain which forms the whole it will be found that no one link is a particular departure from a practice that has existed many years. It has simply been the putting together of old principles into a new form. One exception can be made to this statement. The alternating-current railway motor is new, and yet an exposition of its characteristics, such as in its speed and torque curves, shows that within it the old underlying principles prevail. Its complements, the power house and line, involve no new principles that have not been tried out under various forms and conditions. A high-tension moving contact has nothing new or of a disturbing nature about it.

When the form of electrification of the New York division came up for decision, there was an easy path of the least resistance open to the engineers of the New Haven system. A form of electrification had been adopted and applied to traffic rails over which the New Haven trains were obliged to go in their entrance to New York City. An acceptance of this form of electrification would have simplified and made easy the duties and responsibility of the engineers of the New Haven road. The right path, however, is not always the easiest, and the principles which existed in their minds were of a character that required a radical departure from the easy and tempting alternative. There is an old saying, "Nothing that is worth while ever came easy," and such has been the case with the New Haven line. They have encountered unexpected difficulties, which are always common to initiative; none of them, however, has been of a character which could be interpreted as a menace to the general principles involved. The difficulties have either been corrected or their correction is easily in sight.

The last six months of operation have offered the opportunity for a collection of valuable data, and the following observations and recommendations are offered in the hope that they may be of some value to other engineers interested in the electrification of steam railways.

1. In one, two, three, or four-track railways, the single-phase distribution should include, besides the trolley wires, by-passes or feeders.

2. Electrical sections should not average less than 1.5 miles in length; greater averages are entirely acceptable and individual lengths should be governed by local conditions.

3. Twenty-two feet is a safe general working distance of trolley from rail.

4. The de-insulating effect of steam locomotive stack discharges is a most important consideration to be kept in mind in the matter of properly insulating high-tension wires from ground.

5. High insulation factors should be used where high-tension construction due to low bridges is brought nearer the rails than the normal height of 22ft. Strong mechanical shields should be used to deflect locomotive blasts from messenger insulators at low bridges. Care should be exercised in the installation of these shields so that high-tension conductors and ground are at safe working distance. Wherever possible insulators should be installed away from the direct line of the locomotive blast.

6. Auxiliary wires in connection with the electrification, if they cannot be carried over highway bridges as aerial conductors, should not be carried under, unless they are enclosed in lead-covered cables, with end-bells properly enclosed in suitable housings at points where the conductors change from aerial to lead-covered cables.

7. All circuit-breakers connecting feed wires (or by-passes) to the trolley bus-bars should be equipped with time-relays, so that any short-circuit will immediately open the trolley-breakers, thus locating the trolley section grounded. Equipping the feeder breakers with time-relays ensures continuity of voltage on wires not affected by the short-circuit. Each trolley-breaker pilot-switch should be provided with a light to indicate when it opens, and an announcer bell should ring in the signal tower at the same time so that the operator is promptly notified.

8. On account of deleterious influences of weather and locomotive stack discharges, together with general inconvenience of getting at bus-bars and switches when

installed on anchor bridges, all section oil-switches should be installed in switch houses erected at the side of the tracks, with lead-covered cable connections between trolley and switches.

9. Signalling should be arranged so that the operator can prevent the engineer from spanning two sections by his locomotive shoes in the event of the advance section being grounded

10. All signal towers should be interconnected with a reliable telephone service. Immunity from electromagnetic and electrostatic disturbance in the telephone system can be secured by using twisted-wire pairs enclosed in lead-covered sheath, the sheath being grounded frequently. This suggestion is more particularly applicable to the interrupted or tower-to-tower telephone system. In this case the distance of exposures of the telephone wires is not great, and thus the aggregate effect of electromagnetic induction is negligible. In the case of the through telephone line where the circuit is uninterrupted throughout the zone of electrification, again the lead sheath and twisted pair are respectively effective in removing all static charges, and electromagnetically balancing the circuit ; but on account of the cumulative action of the electromagnetic induction, either compensating transformers or a system of impedance coils installed across the telephone circuits at intervals of two miles (this distance may be less, depending on the electromagnetic density) with their central points grounded should be used. Either method will satisfactorily remove the impressed voltage due to electromagnetic induction. The importance of reliable telephone service between operating towers cannot be too greatly emphasized.

The above-mentioned are some of the fundamental requisites which design and practice have brought out in connection with the New Haven electrification. Except for certain minor and easily remedied details, experience to date with the New Haven arrangement of single-phase distribution would indicate that the fundamental principles involved have been correctly applied.

* * *

CANADIAN SINGLE-PHASE RAILWAY.

THE first company to adopt single-phase railway equipment in Canada was the Windsor, Essex and Lake Shore Rapid Railway Company, which is now using single-phase cars between Windsor and Kingsville, Ontario, a distance of twenty-eight miles. The single-phase system is being further extended from Kingsville to Ludmington, a distance of nine miles.

The system carries express parcels as well as passengers, and is arranging to carry goods. At present the rolling stock includes five motor-cars, four passenger trailers, and two trailers for express. The trailers are not regularly used, and not more than one is drawn by a single motor-car. There are on each motor-car two 100h.p. Westinghouse single-phase series motors. These motors are provided with compensating field coils for neutralizing the armature reactance. The regular Westinghouse pantagraph collector is used on the cars. It is raised by means of springs under tension and is pulled down by a trolley rope. The motor-cars are provided with air-brakes, and two cars are now being equipped with air-operated pantagraphs. The air compressor is driven by a 3.3h.p., single-phase, 100-volt motor.

A complete diagram of the wiring of the cars is shown in Fig. 1. It will be noticed that provisions have been made to take energy from the wire both at 1100 volts and and at 6600 volts. Only one of these voltages, however, is used, although when the equipment was bought it was intended to use 1100 volts in the city of Windsor, and to supply energy at 6600 volts for the rest of the line. As permission was granted to use the higher voltage at Windsor, a

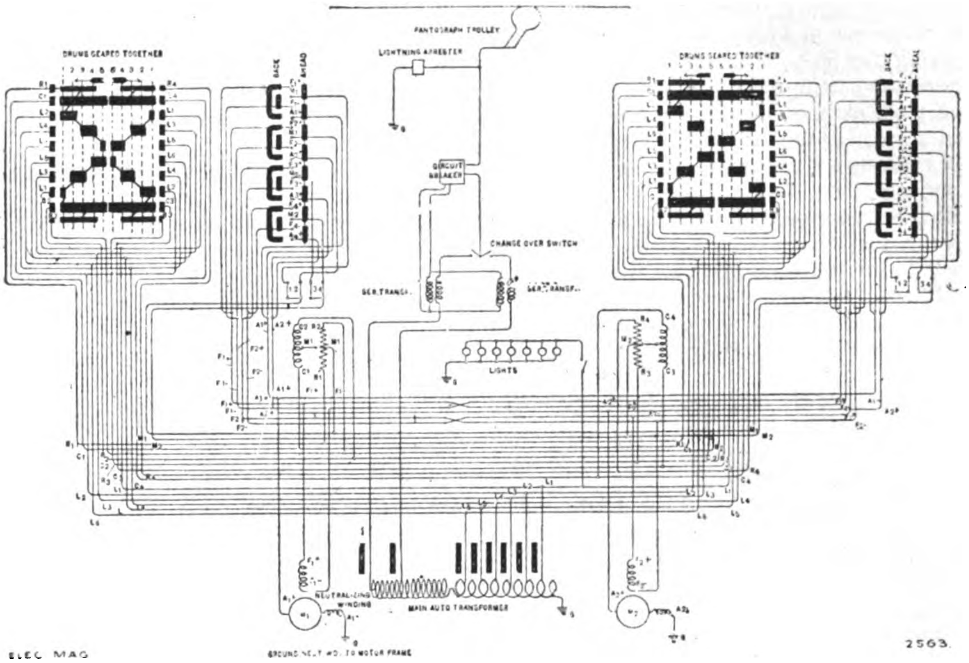


FIG. 1. DIAGRAM OF SINGLE-PHASE CAR WIRING.

change-over switch is no longer necessary, and only one lead to the auto-transformer is used. If the necessity should ever arise, 1100 volts can be used at any point without altering the car equipment.

The connection from the pantagraph to the circuit-breaker is made with lead-sheathed, rubber-insulated cable. The resistance coils, *R* and *C*, are connected between the controller segments and the armature to minimize sparking at the controller. The auto-transformer is of the oil-insulated, self-cooled type, rated at 100kw.; there is one to each car.

The contact line is of catenary construction, with poles set 120ft. apart on the tangents and as close as 80ft. on the curves. Bracket construction on the poles is used exclusively, except where the line passes through towns. The trolley wire used is 000 grooved. The hangers from the messenger wire to the trolley wire are spaced 10ft. apart. Where the bracket construction is used, the messenger wire rests in the groove of the insulator, which is fastened to the T-bracket arm. The hangers cause the trolley wire to remain below the arm, and no further insulating devices are necessary on these poles, except where there is a lateral strain on the wire. Where this is the case, and on all curves where brackets exist, a steady-strain device of the wooden-arm type is used. The porcelain insulator holding the steady-strain rod is carried in a malleable iron yoke which is adjustable on the bracket arm. The steady-strain rod is made of a thoroughly impregnated wooden rod having malleable iron end-lugs. This is used instead of a sleeve type in order to bring the trolley wire closer to the bracket arm. In addition to using these on curves, they are fitted at 12-pole intervals on the tangents.

Since the messenger and the trolley wire are both electrically connected, at each section break, it is necessary to open the circuit on both of these conductors. The messenger wire is cut at the point of the change of circuit, and the ends are fastened to separate wire insulators, the insulators being suspended from the insulator arm of the bracket. To open the circuit upon the trolley wire, a piece of second-growth hickory, treated to make it moisture-proof, is introduced into the line. The ends of this block are provided with terminals, into which the ends of the trolley wire are fastened, the construction of the terminals and the shape of the wooden bar being such that the trolley passes smoothly from one circuit to the other across the intervening space without leaving the line. The arc is broken on the terminal casting. Line section-insulators are used at the sub-station, one at Kingsville, and near the car shed. The latter insulator allows all the wires in the yard to be connected or disconnected without interfering with the rest of the line. A separate switch for controlling the yard circuits is installed in the power house.

It is found that the men can work with perfect safety from a repair tower, even when the voltage is on the line, by using a platform mounted on four double-skirt insulators, such as are employed on the poles for span-wire construction. The cross-span construction is of the steady-strain skirt type. In this type of construction the only insulators ordinarily used are those on the poles, the span wires being connected to the trolley at all times. In the present installation there was inserted in the span wires, at a distance of 3ft. from the catenary structure, a wood strain-insulator, which makes the span-wire "dead" except for 3ft. on each side of the trolley wire.

The poles in the city of Windsor have been made of concrete. Each is required to withstand a horizontal strain at the top of 1000lb.

The catenary structure conveys all the energy required as far as the sub-station at Mirdstone, a distance of eighteen miles, at 6600 volts. At this point there is installed an auto-transformer, which receives energy from the power house over a special transmission wire at 13,200 volts, and reduces the e.m.f. to 6600 volts. The transmission line is supported on the same poles with the trolley wires, except in a few instances where it is placed on a special line of poles on account of trees. A diagram of the wiring of the sub-station is shown in the right-hand lower corner of the switchboard diagram, Fig. 2. The transformer is rated at 300kw.; it is oil-insulated and self-cooled.

The power house is situated at Kingsville by Lake Erie, from which water for the condensers is pumped. The main part of the building, which is the engine room, is of brick. The walls of the boiler room and the division wall between the boiler room and engine room are made of concrete blocks. The chimney is of radial brick.

There are two cross-compound engines, 20in. by 40in. by 36in., manufactured by the Goldie & McCulloch Company, of Galt, Ont. These engines are provided with steam-actuated dash-pots, and have separate eccentrics for the steam and exhaust valves. The speed is 125r.p.m. The governor is belted to a pulley on the main shaft, and is similar in action to a flywheel-type governor. The generators are 500kw., 25-cycle, single-phase Westinghouse machines, direct-connected to the engines. The exciters are 30kw. machines, belted to the main engines. Space is left for one more complete unit similar to the above in the engine room.

There is one jet condenser for each engine, size 16in. by 24in. by 24in. The injection water, as previously mentioned, is drawn from Lake Erie, through two 10in. pipes. One condenser has a lift of 22ft. and the other 19ft. The distance from the power house to the end of the intake pipe is 500ft. The end of the pipe was placed 100ft. from the foot valve in order to obtain good, clear water. The pipes are attached to the side of a pier with bolts. In order to keep solid matter from getting into the pipes, an extra piece 3ft. long with a cap was screwed on the end, and the pipe as well as the cap perforated with ½in. holes.

The horizontal pipe from the foot valve to the end was set 2ft. below the average level of the lake to ensure getting water when the lake at this point became low, as is frequently the case during north-west winds. In order to get the pipe down to this depth, it was necessary to dig a trench for about 75ft. under water, which is very shallow near the shore. This work was done in the winter, a scoop scraper pulled by horses being used, and the men holding the scraper walking on the ice. The foot valve was kept down at the same depth as this pipe, thus ensuring its always being under water. A manhole was built around the foot valve, from which the water can be pumped should any repairs here be required.

The two condensers feed into a common hot well, the overflow from which discharges into a 14in. pipe back to the lake.

In the boiler room there are four 360h.p. Canada Foundry Company water-tube boilers, and there is room for two more. There are two Cochrane feed-water heaters supplied with water from the hot well by a 10in. by 6in. by 10in. Blake duplex pump, and these heaters are supplied with the automatic attachment for regulating the feed from the hot well by placing this pump in

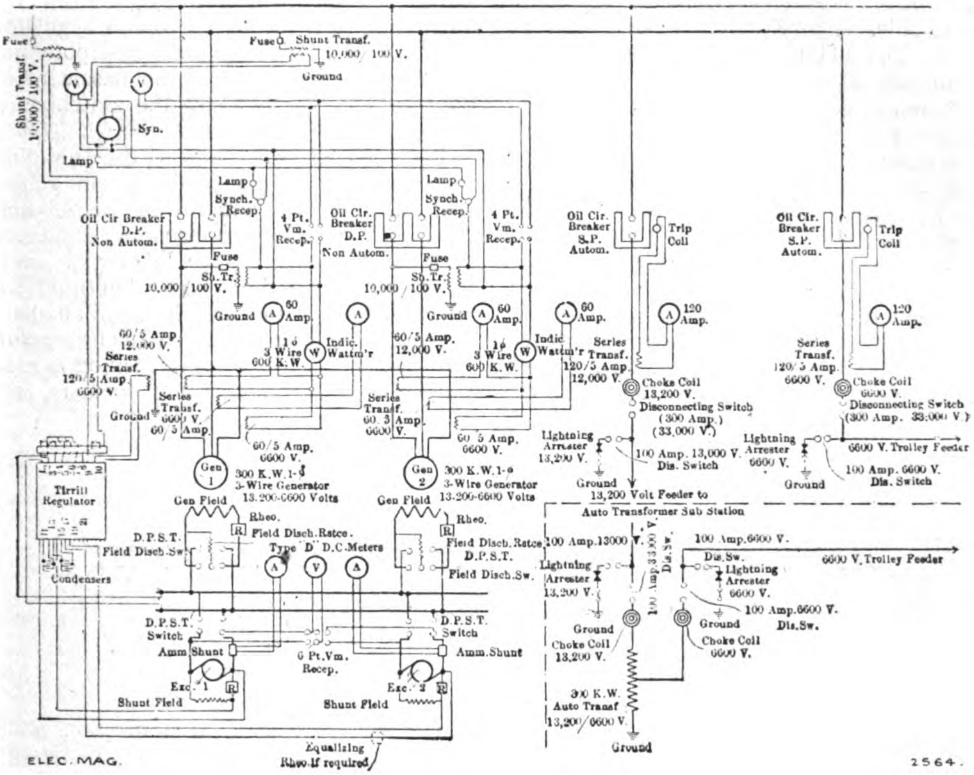


FIG. 2. DIAGRAM OF MAIN SWITCHBOARD AND SUBSTATION CONNECTIONS.

and out of service as the water is needed. The boiler feed pump is of duplex type, size 7½in. by 4½in. by 10in.

It is now being arranged to use natural gas for boiler firing, and under one battery of boilers is being installed twenty-six 5in. Gwynne burners. These are to receive oil through a 6in. supply pipe at a pressure of 10oz. per square in. The other battery of two boilers will not be equipped until these prove satisfactory.

It may be interesting to state the comparative costs per h.p.-hour running with and without the condenser. Up to the time the condenser was put in service (Nov. 19, 1907) the average cost of operating the plant (non-

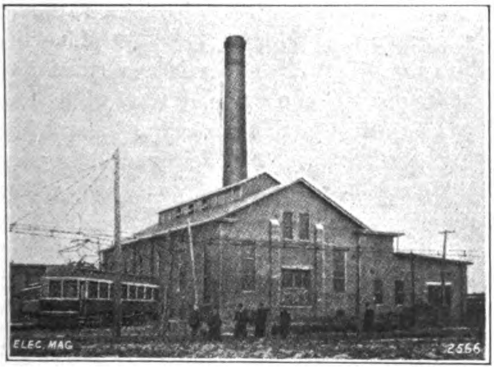


FIG. 3. POWER HOUSE AND CAR SHED.

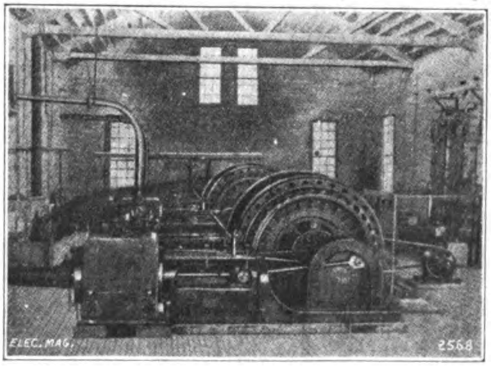


FIG. 4. INTERIOR OF POWER HOUSE.

condensing) was 1.155 cents per h.p.-hour. From Nov. 19 to Nov. 30 the cost was .708 cent. These figures are given only to show a comparison between running condensing and non-condensing, and do not represent what will be done under better conditions. The steam pipes had not then been covered, and the average load was a little under 50 per cent. of the full rating of the machines.

In the switchboard arrangement there are three wires from the stationary armature of each generator—one earth wire, one carrying energy at 6600 volts and the other at 13,200 volts. Both the latter wires are lead-sheathed, rubber-insulated cables, and are run to the switchboard in fibre conduit. This conduit is designed to withstand over 34,000 volts on a puncture test. A Tirrell voltage regulator is used. The resistance coils and potential transformers are placed in the basement of the building directly below the switchboard apparatus.

Each feeder wire enters the building through two glass plates set in 10in. glazed tile. Both outside and inside the building the wires are fastened to insulators supported on a bracket structure made of 3in. angle irons bolted together. The lightning arresters, disconnecting switches, and auxiliary apparatus are mounted on an oak framework well shellacked. The same method is used for incoming wires, lightning arresters, &c., at the sub-station.—*Electrical World.*

* * *

AN IMPROVED FORM OF INDUCTION STEEL FURNACE.

A MODIFICATION in the design of electric induction furnaces for steel refining has been developed by Messrs. Roechling and Rodenhauser and was described by H. Wedding in a recent number of *Stahl und Eisen.* The following particulars are from a translation published by *Electro-Chemical and Metallurgical Industry.*

The furnace is intended to refine molten steel received from the basic lined converter and to produce in continuous operation soft iron which is at least equivalent to Swedish soft iron. Prof. Wedding and others had an opportunity of seeing the furnace in operation. During this inspection heats of very different character were made. According to the desires of the visitors sometimes a very hard, sometimes a very soft, and sometimes medium hard steel was made and cast into moulds of different forms. In all cases the steel from the basic lined converter was the starting material. It was supplied to the electric furnace in molten form, and was not only decarburized but also deoxidized and recarburized. The chief new feature of the Roechling-Rodenhauser furnace, which distinguishes it from the Colby-Kjellin design, is that it combines two methods of electric heating: first, the ordinary heating by electric induction currents, while the second kind of heating also employs induction currents, which, however, are introduced into the molten bath through metal plates called electrodes. This second method of heating has, therefore, some similarity with ordinary alternating-current resistance furnace practice.

The furnace is shown in Figs. 1, 2, and 3. Fig. 1 is a horizontal section along the line *a b* of Fig. 2. Fig. 2 is a vertical section along the line *e f* of Fig. 1, while Fig. 3 is a vertical section along the line *c d* of Fig. 2. The furnace is designed for a 5-ton charge, to be operated at 5000 volts with a frequency of 15 periods per second.

Like the ordinary induction furnace, this furnace is essentially a transformer with a single primary winding *A* around both iron cores *H* of the transformer. The secondaries are two in number, one is the molten

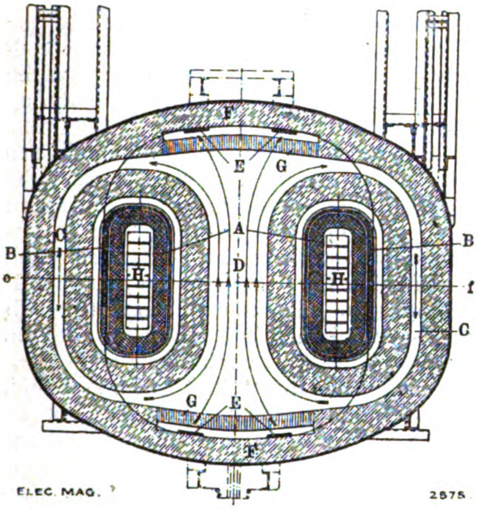


FIG. 1.

bath C in the form of ∞, the channel D between the two cores being very broad. The other secondary is the copper winding B, which is connected with the metal plates E. These metal plates are inserted into the furnace walls F in such a way that the currents pass from the winding B through the plates E, and through the mass G of highly refractory electrolytic conductors (of the same nature as used for filaments in the Nernst lamp) to the molten mass D. In this way the molten mass D is subjected to a double heating effect, one direct by induction and the other from the currents passing between the opposite sets of electrodes E. The direction of the currents in the bath at a certain moment is indicated by arrows in the illustrations.

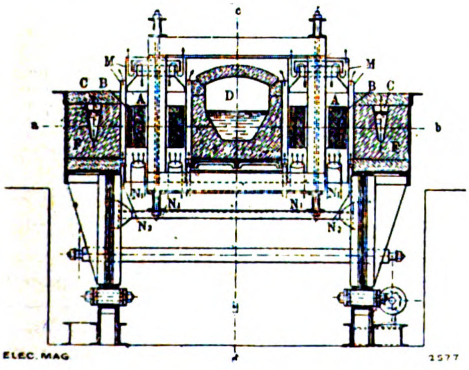


FIG. 2.

In order to protect the windings against the effect of high temperatures, thin walled copper cylinders $M M$ (Figs. 2 and 3) are provided, through which is conducted an air blast passing out of the tubes $N_1 N_2$. The transformer iron contains ventilation slits H (Fig. 1). These methods of cooling have been found to be perfectly sufficient during several months' operation.

The charging door is at one end of the furnace, the tapping door at the other end. On account of the method of operation of the furnace the molten charge is kept in sufficient circulation so that all manual operations are restricted to taking care of the right formation of slag and to the tapping of the slag. As shown in Fig. 3 the whole furnace is built as a tilting furnace. In its general design the furnace is built very much like a Siemens-Martin open-hearth furnace.

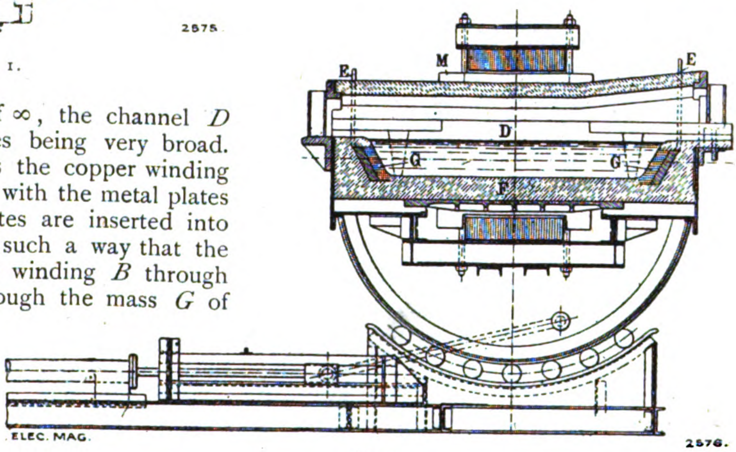


FIG. 3.

The normal charge is 3 to $3\frac{1}{2}$ tons, but about 800kg. are left at the end of a heat in the furnace, so that the new charge consists of only $2\frac{1}{2}$ tons. This is being done in order to keep the furnace hot, when after the conclusion of a heat no fresh charge is yet ready for introduction from the converter in the electric furnace.

The operation of the furnace is as follows: After providing a basic lining of magnesia with 10 to 12 per cent. tar of the hearth and around the transformer cores (the arch consisting of firebrick), the inside of the furnace is first strongly heated. For this purpose rings of soft steel are placed in the furnace, which are heated to 900deg. to 950deg. C. by induction currents. As soon as the furnace ceases to give off smoke (the hydrocarbons from the tar having been driven off), fluid pig-iron is introduced from the blast furnace. The electric circuit is then closed and the temperature begins to rise slowly. After eighteen hours the furnace is up to full heat, and there is no longer any smoke.

The molten pig-iron is then removed by tilting the furnace, only 800 kilograms remaining back, and now the finished steel from the basic converter is introduced. Burnt lime is placed on this bath. The lime used contains 6 per cent. magnesia. About 8 kilograms of fluorspar are added to get a sufficient degree of fluidity in view of the comparatively high content of magnesia. Refining now begins. If the slag becomes too fluid, lime is added; if too thick, fluorspar.

The operation is completed when bubbles no longer rise up from the liquid bath, and when samples taken from the bath give satisfactory tests. The slag, which contains generally 25 per cent. of iron, in form of oxides, is removed and a pure lime slag is formed from fresh-burned lime and fluorspar and deoxidation begins now by means of ferro-silicon. Samples are taken again and tested. If the intention is to make high-carbon steel, powdered coke is added to the furnace, which quickly dissolves in the bath, otherwise spiegeleisen is added as usual.

The final slag has the following composition :—

	Per cent.		*Per cent.*
FeO	5.32	Fe_2O_3	0.94
MnO	0.9	Al_2O_3	1.27
CaO	67.82	MgO	3.88
SiO_2	0.97	P_2O_5	0.6
S	0.9		

The alumina comes evidently from the firebrick of the arch.

To make hard steel free from sulphur the steel must be left in the furnace for a longer time, and the sulphur must be removed by oxidation or manganese and a suitable fluid slag. As analyses show, the sulphur may be completely removed in that way. Very small quantities of manganese are sufficient, but it is necessary to employ a high temperature, which can be accomplished easily by raising the voltage.

Compared with converter steel the electric steel when being cast runs exceedingly quiet, which is due to the fact that the steel has a very high temperature during casting.

With the electric furnace it is possible to remove completely all impurities from the steel. If the object is to bring the content of phosphorus below 0.02 per cent., it is necessary to remove the second slag and form another third slag like the second. If the content of silicon has become too high it is easy to reduce it again by an addition of "Walzsinter," lime and fluorspar.

A complete removal of silicon should, however, not be attempted, because otherwise the iron does not get sufficiently dense in the mould. In spite of a content of 0.085 per cent. silicon with 0.47 per cent. manganese, a very quietly running and thoroughly dense steel is obtained when the content of carbon is only 0.01 per cent. An analysis showed in such a steel 0.03 per cent. of phosphorus and 0.77 per cent. of sulphur.

Each heat lasts in general for two to three hours. Two men are sufficient to do the work at the furnace, while a third man attends to the electrical equipment. During tapping the circuit is broken so that the current, e.m.f. and power become zero. Otherwise they remain practically constant during operation, and are regulated only if for some purpose it is intended to raise or reduce the temperature. The conditions during a heat which began at 10.50 A.M. are given in the following table :—

Hours.	Minutes.	Volts.	Amperes.	Kilowatts.
10	50	2600	145	330
11	00	2800	150	365
11	10	3000	165	430
11	20	3000	165	430
11	30	3200	170	460
11	40	2800	152	375
11	50	2600	142.5	315
12	00	2000	142	330
12	10	2400	128	250
12	20	2400	130	270
12	30	2400	131	210
12	40	2400	131	210

Tapping was then begun, and after a new charge had been introduced the conditions were as follows :—

Hours.	Minutes.	Volts.	Amperes.	Kilowatts.
12	55	2600	40	80
1	00	2600	130	310

The above figures show that the power factor is quite satisfactory. At 2600 volts, with a current of 145 amperes, the volt amperes were 377,000, or 377kv. amperes, while the kilowatts were 330. The power factor (or the cosine of the phase difference between e.m.f. and current) was therefore 0.875. Several analyses and results of mechanical tests are given.

Concerning the cost of the process, figures are given for a five-ton furnace, and it is found that the total cost of refining one ton of soft steel in the electric furnace (including interest and amortization, but not including licence fee) is 24s. ($5.83).

This process, like other electric steel processes, serves simply for refining. It enables one to remove the last impurities from the steel and to introduce any amount of carbon and other elements. Above all things the electric furnace is a substitute for the crucible process by removing all gases, but has not the disadvantage of the crucible process, namely, the absorption of silicon from the crucible walls. If the product is worth about 29s. ($6.00) more per ton than the converter steel which is introduced into the furnace, the process is economical on a large scale. That the product is worth so much more must be concluded from the denser structure which manifests itself at the very high temperature, and which has an influence on the condition of the carbon that still remains to be investigated.

High-speed Electric Lifts.

As the home of the "sky-scraper" America has seen the greatest development of high-speed electric lifts or elevators. The following details are of interest as occurring in a paper presented by Mr. J. H. Ihlder, engineer of the Otis Elevator Company, before an American scientific society last month.

The development of the electric elevator for use in the higher buildings has been rather slow. Until the present time the hydraulic elevator has almost entirely monopolised this field. Since 1890 electric elevators have slowly come to the front. Difficulties that have had to be overcome were the complexity and unreliability of controllers, the high speed of the motors requiring reduction gearing, and the unsatisfactory nature of high-speed-drum rope driving. Now that slow-speed motors and good controllers are available, a return to simplicity in design is attainable with the result that the gearless, one-to-one, traction electric elevator is now the most formidable rival of the hydraulic machine.

In this traction electric elevator, which is particularly adapted to high-speed service in high buildings, the motor is usually installed at the top of the hatchway, although in some cases it is placed in the basement. Four to six ⅝-in. ropes are generally used. They are run up from the car, over the driving sheave, around an idler sheave, again over the driving sheave and idler, and finally down to the counterweight. Each rope thus makes two half-turns over the driver, which has been found amply sufficient to give the maximum tractive effect required. The idler sheave gives a convenient way for directing the ropes so that the counterweights may be run in any desired portion of the hatchway, and at the same time affords a means of bringing the ropes to another portion of the driver for their second half-turn about it.

The motors used are either straight shunt or of the cumulative compound type, in which the series field is in action only at starting to give a better starting torque, and is effectively cut out as soon as running speed is attained. The motors are usually about 35h.p. and run at 60r.p.m. with a maximum efficiency of 87 per cent. and an average efficiency over 80 per cent. from 6h.p. to 40h.p. The method of control is simple and automatic. In stopping, the armature is short-circuited by a low resistance and thus acts as an effective electric brake. The operator cannot lose control of his car. Safety switches at limiting points near top and bottom of the hatchway cut off the power and apply an automatic brake. Other usual safeguards are provided as well as special oil buffers at the limits of motion of the car and counterweight.

In comparing the electric and hydraulic elevators it is to be noted that the former consumes power proportional to the load. This is not true of the hydraulic machine, whose energy consumption is almost constant regardless of its live load. The traction-type electric machine does not vary in speed with load as does the hydraulic. It also makes a more rapid start and stop and therefore gives a higher speed service. Furthermore, it is equally as safe as the best hydraulic elevator.

MANUFACTURING Progress

A classified list of articles important to Manufacturers will be found in the World's Electrical Literature Section.

New London Showrooms and Depot.

Simplex Conduits, Ltd.

Towards the close of last year Messrs. Simplex Conduits, Ltd., opened larger and more convenient London premises in Charing Cross Road. This well-known thoroughfare has of recent years become quite a recognised quarter for firms dealing in electrical goods; numbers 113, 115, and 117 constitute a large four-story building erected quite recently, and the Simplex Company has secured the entire basement and ground floor, aggregating over 3000sq. ft. of floor space, in addition to which there is a commanding frontage of 50ft. comprised of three large windows and two entrances.

The ground floor constitutes the showroom and offices, the necessary divisions being carried out by means of opaque glass partitions. The showroom is situated in the centre, the offices being on each side and opening into the showroom itself. The whole of the paint work and partitioning is carried out in white in order to give the maximum light, as the sole source is through the front windows, and as in the cases of some of the offices situated at the back, daylight is filtered through three sets of glass, so that it is essential to obtain some advantage from reflection.

The showroom is equipped with the idea of giving maximum flexibility; that is, to facilitate rearrangement of the various samples and fixtures displayed. The value of constant change in this regard cannot be over estimated. Nothing is calculated to arouse more interest in a customer than the idea that he is seeing something new on each occasion of a call, and it is claimed that in this case an entirely fresh appearance can be given to the showroom within an hour or so. No apparatus is permanently fixed in position, a circumstance which has been considerably assisted, if not rendered necessary, by the nature of the building itself. It happens to be built entirely throughout on fireproof principles, to the L.C.C. regulations, which in many respects are peculiar. Thus the ceiling of the showroom is of concrete 1ft. thick, with an iron girder every six inches, in addition to which there are two 18in. by 10in. girders supporting and projecting from the ceiling. To attach electric fixtures to this would naturally have entailed a tremendous amount of labour and cutting away. The difficulty has been obviated by fixing three parallel lengths of $\frac{3}{4}$in. Simplex conduit hung 20in. below the ceiling so as to clear the girders above referred to, and seven feet apart. Across these are laid at right angles several runs of $\frac{3}{4}$in. conduit, along which are interspersed wall sockets mounted on flange couplings. These runs are wired in two sections to a two-pin plug at each end.

All types of electric light pendants and electroliers, of which there are a number, some of unique and striking designs, are attached to the cross tubes. They are wired complete to a plug so that they can be readily put into circuit by connection to one of the sockets. The plugs at the two ends of the circuit wires of the tubes are carried down the partitions to another wall socket fixed on a small shelf, which surrounds the showroom at a convenient height. The wall socket is wired directly from the main distribution board.

It will be seen that half-a-dozen fittings can be thus readily lighted up for display purposes, whilst if it is desired to have one

THE NEW SIMPLEX SHOWROOMS AND STORES.

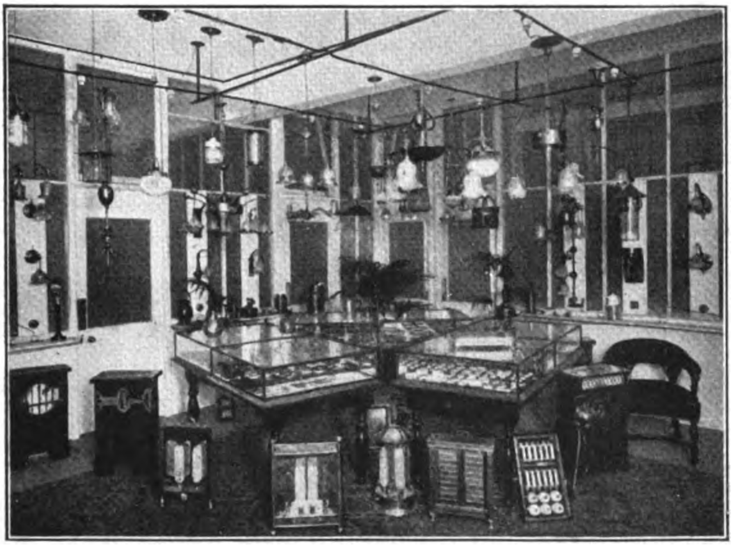
only lighted in order to obtain a better idea of its effect, this is easily accomplished by disconnecting the other fittings from the sockets in the same overhead run. As all pendants are attached by **S** hooks, their position can be altered in a few moments.

Brackets and wall fittings are attached to wood panels fixed in the lower frames of the partitions; these panels are all interchangeable, and are arranged so that they can be readily removed and altered. Brackets, etc., are also wired to plugs for connection to the sockets on the shelf before mentioned.

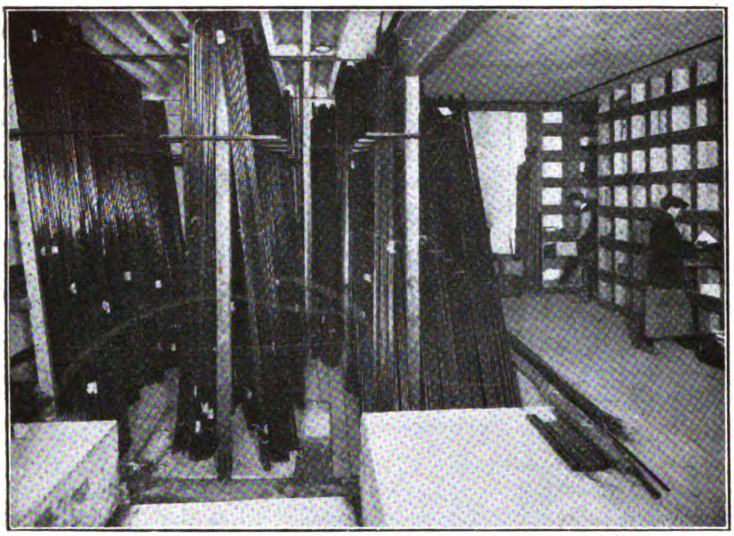
The arrangement of the windows is carried out on a similar plan. Every piece of lighting or heating apparatus is fitted with a plug for connection to a socket. The latter are arranged in groups of six, flush sunk in Simplex cast-iron boxes, and controlled directly from the main board. From the point of view of flexibility the arrangement is an excellent one, and strikes out in a somewhat novel line when compared with the style on which the general run of showrooms for electrical goods are laid out, although, perhaps, from the display point of view, something is lost, owing to the fittings not being attached direct to the ceiling; but taking into consideration the numerous constructional difficulties met with in the building the utmost use has been made of the opportunities at disposal.

All types and descriptions of accessories comprising the Simplex system are displayed, and a number are fitted up to give practical illustration as to their use.

The main example of the conduit system is, however, given by the lighting installation of the premises, which has been carried out with a view to combining as much as possible typical examples of "how things should be done." Especially is this noticeable at the main lighting board controlling the ground floor. The whole of the various runs are brought to a point on the ceiling above the board and collected in an adaptable box; from this the circuits are taken down to the board in four tubes. The board itself is a d.p. fuse and s.p. switch wood-cased type. The fuses are of the enclosed



ONE OF THE SIMPLEX SHOWROOMS.



The Simplex Conduit Storeroom.

cartridge pattern mounted on separate slate bases and controlled by "rapid action" switches; it is an example practically representing the highest class of distribution board design.

Another interesting piece of work is to be seen in the basement where the supply company's mains enter the building. Two main fuse-boards of different patterns are installed, one controlling the power supply and the second for the basement lighting. The main switches and fuses are of the "push on pull off" type of combined switch fuse.

The whole premises are electrically heated throughout; different styles of convectors or radiators are used in each room in order to give increased range of examples for customers' inspection.

A complete range of cooking apparatus, kettles, &c., is also displayed. The heating appliances cover several useful types of convectors of a wide range in price, but special attention has been paid to luminous radiators. Some of these are of distinctly original lines, and special mention should be made of the wall bracket pattern, which should prove most popular.

A wide range of incandescent lamps is shown, together with a new metallic filament lamp, two in series on the 200 volt circuit.

To that most important department—the stores—which is in the basement, there is over 1600 sq. ft. in area. Larger stocks than hitherto can now be carried with a view to increasing facilities; for this the Company found it necessary to excavate a portion to the extent of 3ft. in depth, in order that the tubes could be stored upright. The extra quantity that can be stowed away in this way as compared with the horizontal rack system is enormous.

Three-phase Starters.

Marples, Leach, & Co.

This company has just placed on the market a new type of star-delta three-phase starters which exhibit several noteworthy features. The starters are intended for use with the smaller sizes of three-phase motors with short-circuited rotors. The principal advantage of their construction lies in the fact that when in the "off" position all the stator windings are cut out of circuit, so that no auxiliary three-pole switch is required in addition to the starting gear, as is the case with other types of star-delta switches. In general the new starters are constructed as quick-break switches consisting of nine contact springs mounted side

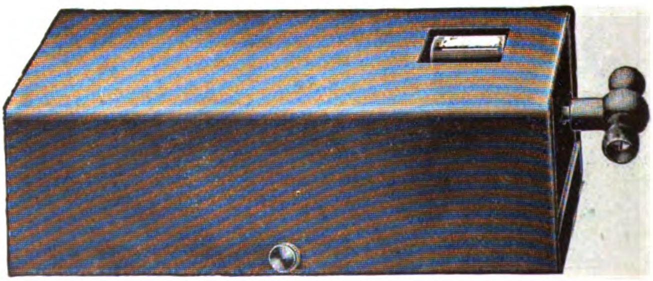


Fig. 1. Three-phase Starter Complete.

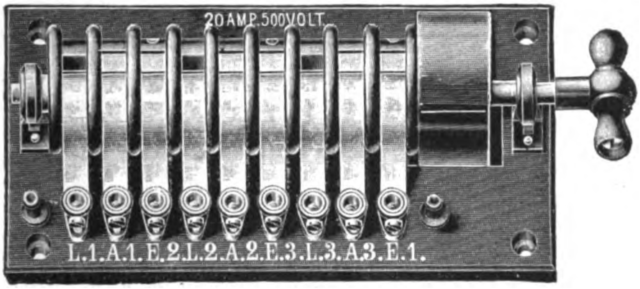


Fig. 2. Three-phase Starter with Cover removed.

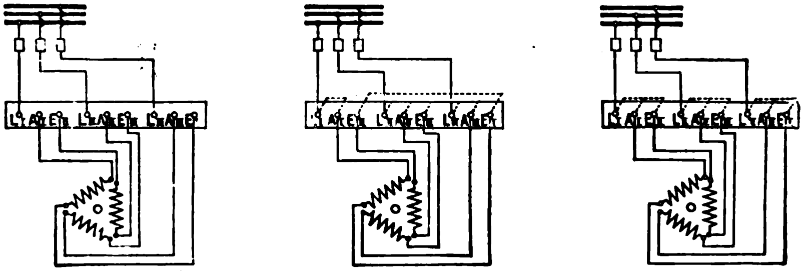


Fig. 3. Connections showing operation of Three-phase Starter.

by side on a baseplate of insulating material and separated by means of insulating discs. These springs make contact with nine copper-clad porcelain stars connected up as shown in the diagram Fig. 3.

The complete switch is fitted with a sheet iron cover insulated on the inside. It can also be made water-tight or dust-proof. A rotating disc indicates the position of the switch at any moment. The apparatus is made in two sizes, namely, 20 and 30 amps. 500 volts. The switch has a continuous rotary motion and cannot be put in the "delta" position without first going through the "star" position.

The illustrations herewith show—Fig. 1, the starter with cover complete; Fig. 2, the internal arrangement of the starter; and Fig. 3, the diagram of connections in each of the three positions, namely, "off," "star," and "delta."

Oil-Type Switchgear.

Union Electric Co., Ltd.

There is much that is noteworthy in the newest improvements made in the well-known specialities of the Union Electric Company. This is particularly true of the switches and switchboard apparatus generally. The design of oil-type switches in conjunction with automatic attachments has been carried to a very high degree of perfection. Some examples of this work are shown in the several illustrations herewith. The practice of building switch units in the form of a self-contained pillar or pedestal has obvious advantages; and when these are so devised that they can be compactly assembled alongside each other to form a switchboard without introducing difficulties of inter-connections, and yet at the same time preserving easy accessibility with perfect guarding of such connecting mains, their merit is exceptional. The general arrangement of a high-tension switch of this type is shown in the sectional drawing, Fig. 2,

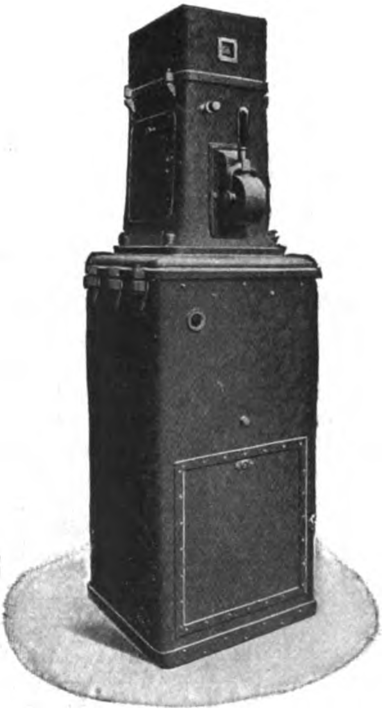


Fig. 1. Oil-type Automatic Switch.

the general appearance of the complete switch being shown in Fig. 1, whilst Fig. 3 shows details of the indicating and automatic trip-gear in the head of the switch, the side doors and hood being removed for this

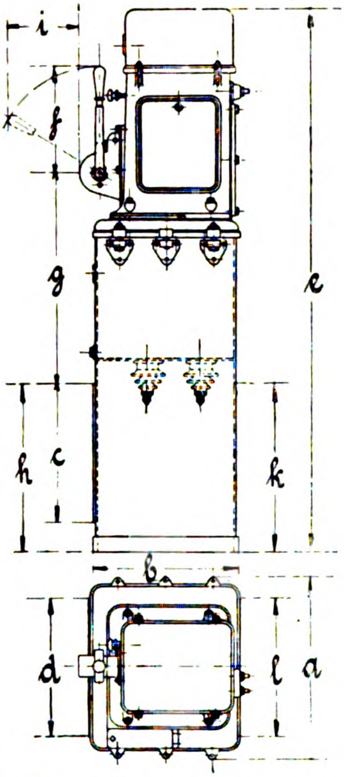


FIG. 2. GENERAL DETAILS OF OIL-TYPE AUTOMATIC SWITCH.

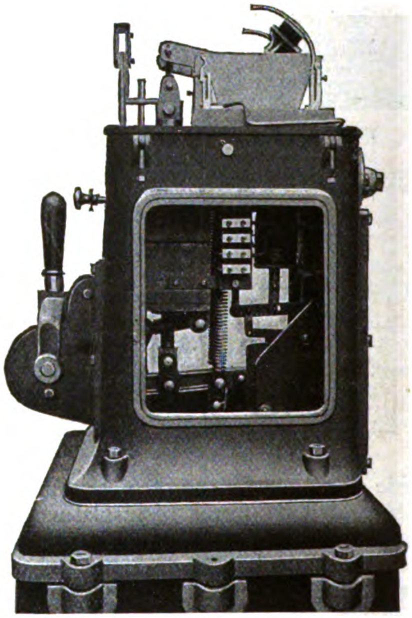


FIG. 3. VIEW SHOWING AUTOMATIC ATTACHMENTS OF OIL-TYPE SWITCH.

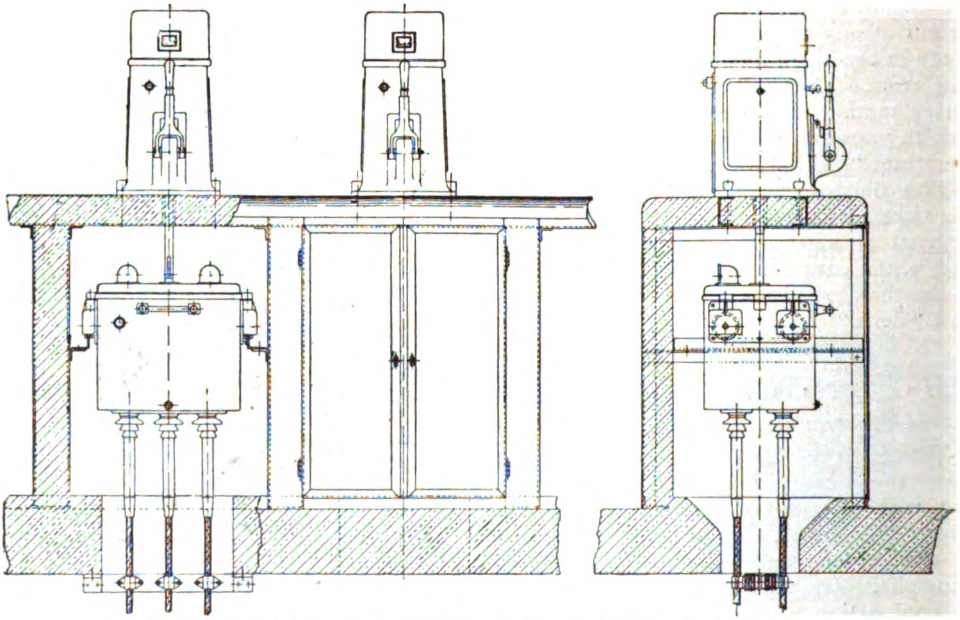
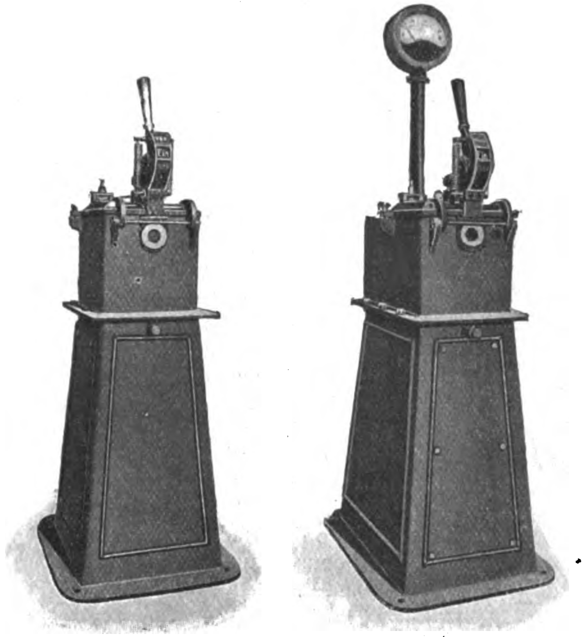


FIG. 4. OIL-TYPE SWITCHES ARRANGED FOR CUBICLE FORM OF SWITCHBOARD.



FIGS. 5 AND 6. SIMPLE OIL-TYPE SWITCHES.

purpose. It will be seen that the oil tank is situated in the upper part of the column or pedestal, the contacts and 'terminals being fixed through the bottom of the tank. The leads to and from the switch are enclosed in the cupboard below the tank; when a number of these switches are assembled together as for a feeder or power distribution switch-board, these doors to the terminal cupboards are interlocked so that they can only be opened when a main isolating switch controlling the circuits of the complete board is opened and the supply cut off every one of the switches. In any case each door is provided with a safe-locking so that accidental contact or tampering with the leads is impossible. Similarly effective precautions have been taken to prevent access to the upper live portions of the switch whilst current is on. The switch mechanism is all assembled in compact form in the upper box or casing, which is hinged to be thrown back, withdrawing the contact blades and plungers out of the oil-tank and affording ready inspection; this top cover is automatically locked down in position whilst the switch is "on," and it can only be released for opening by throwing the switch over to the "off" position.

The simple non-automatic switch of this pillar type is shown in Figs. 5 and 6, the latter having the addition of an ammeter affixed on a strong vertical stand in a conspicuous position.

The automatic devices provided with these switches include overload trip gear, and this again may be supplied with automatic time-lag attachment. The setting of these devices to the desired degree of overload and time interval, respectively, is accomplished from the outside of the switchcase by means of a removable key, the adjustment being indicated on a clearly read graduated scale. For the hand release of the circuit-breaker a push-knob is provided as shown.

For ordinary panel switchboard mounting the Union Electric Company provide the oil-type switches as illustrated in Figs. 7, 8, and 9. The compact arrangement and generally good proportioning of the automatic trip gear are well shown. The releasing and time element gear are similar to those fitted to the pedestal-type switches described. They are positive and definite in their action and are readily set to a

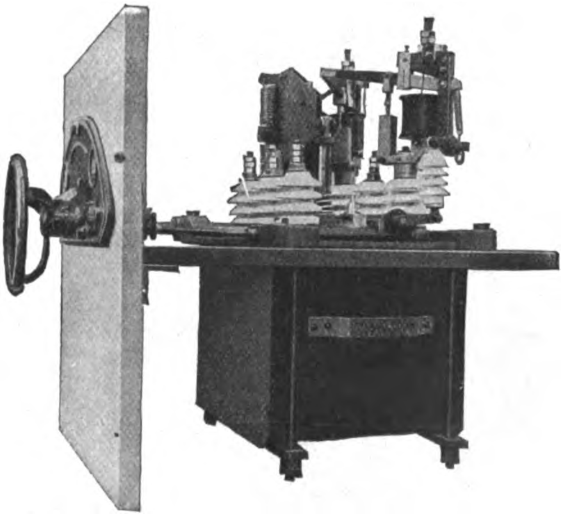


FIG. 7. OIL-TYPE AUTOMATIC SWITCH FOR PANEL SWITCHBOARD MOUNTING.

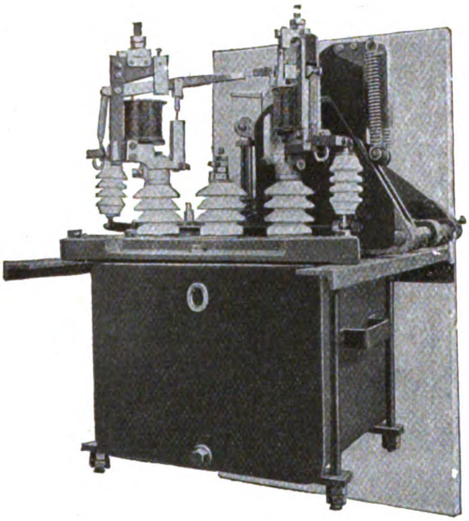


FIG. 8. BACK VIEW OF AUTOMATIC OIL-TYPE SWITCH ON PANEL.

definite degree for operation; the setting key and index to the overload breaker are clearly shown in the illustration of the front plate of the switchboard type, Fig. 9.

There are many other specialities of the switchgear products of the Union Electric Company worthy of detailed description, but space limits prevent more than mention at this writing. They include automatic and hand-operated gear for the remote control of switches; power-operated automatic motor starters and regulators; automatic float-type switches for use with motor-driven compressors, pumps, &c.; an automatic motor-operated cell regulator.

Arc Lamps.

Always known as leading makers of arc lamps for every class of circuit and service of lighting, the Union Electric Company keeps up to date in this department. The latest type of flame-arc lamp evolved is known as the N.Z. lamp. This is a differential lamp with series striking gear, being similar in its operating mechanism to the older A.Z. type. Its normal circuit is 8amps. at 29 volts; it is thus suitable for operation in sets of five or six in series on 200 volt circuits. The carbons are of the usual "salted" flame-arc type with eccentric metal cores, giving a burning capacity of 18 to 20 hours per pair of carbons. The lamp has vertical carbons, the arc being centred in an "economiser" and the light further concentrated by means of a white domed reflector. A particular feature of the Union Electric arc lamps is the new type of cover lately introduced; this is said to ensure absolutely correct ventilation—most important with flame lamps—and yet to afford perfect shielding of the arc from extraneous draughts.

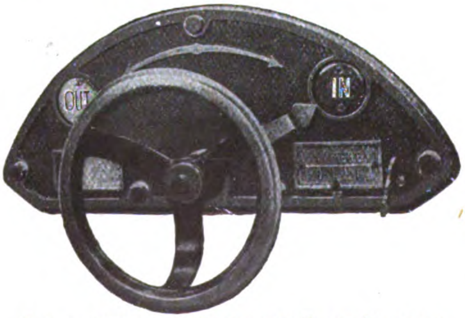


FIG. 9. OPERATING WHEEL AND FRONT PLATE OF AUTOMATIC OIL-TYPE SWITCH FOR PANEL MOUNTING.

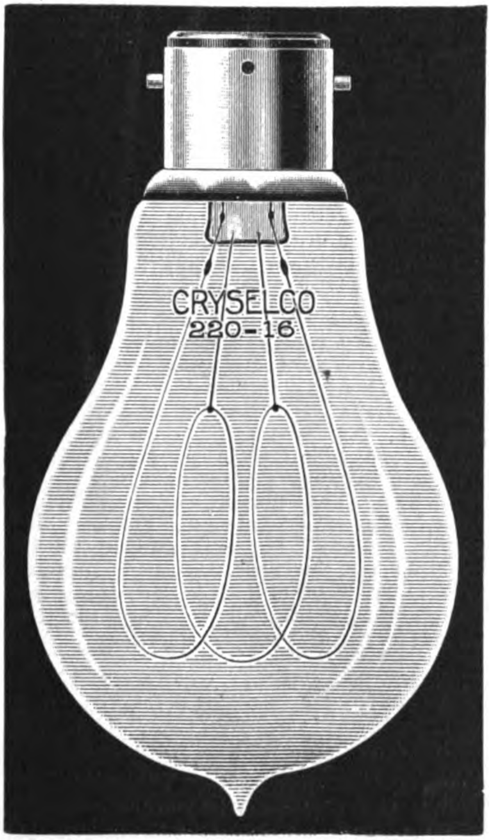
Induction Motors.

A complete new line of induction motors has been introduced by the Union Electric Company; they are built in the usual standard styles of squirrel-cage, wound rotor with slip-rings, and slip-ring rotor with brush-raising and short-circuiting gear; also in the open protected, enclosed ventilated, and totally enclosed types. A further form introduced as a standard is the motor with self-contained speed-reduction gear, second motion shaft, and driving pulley. These motors exhibit no radical departure from standard practice, but it is to the perfecting of detail that their introduction owes its origin. In the slip-ring type the rings are protected by being fitted on the shaft inside the bearing bracket or end bell; in addition to affording protection to the rings and collector gear, this arrangement permits of the ready removal of the outer bearing. The slip-ring short-circuiting device is such that when it is applied the carbon brushes can be raised from the slip rings, thus their wear is minimised, and there is a further reduction of the frictional loss of the machine. The enclosed-ventilated motors are not merely the protected type with end brackets filled in with gratings, but they have solidly enclosed ends, and definite inlet and outlet flues are cast in the motor casing. The latter are provided with substantial hoods, preventing any foreign matter falling into the machine. All these machines are throughout of liberal design, and being available in a wide range of sizes, speeds, and ratings, should meet with great demand. They range in size from $\frac{1}{3}$b.h.p. at 1000r.p.m. up to 300b.h.p. at 375r.p.m., and for voltages up to 5000 volts at the machine terminals.

Incandescent Lamps.

Cryselco, Ltd., Bedford.

THE illustration below shows one of the newest forms of incandescent electric lamp. The "Perfect" lamp, with its lower half frosted and an upper reflector, has met with very considerable demand in this country and the Colonies. It has secured this ready sale by reason of its beautifully diffused lighting effect, and also it is claimed for the reason that it is exceptionally economical in current consumption; it is sold as giving an illumination of 50c.p., with a supply of less than 70 watts, this result being attributed to the particular form of filament adopted, combined with the half frosting of the bulb and the upper white enamelled reflector.



Messrs. Cryselco, Ltd., are well known as makers of a high grade incandescent lamp of standard form as illustrated, and are also engaged in turning out large numbers of special lamps, including those for traction purposes, miners, and for general decorative and exceptional services.

The Electrical Exhibition, Manchester (October, 1908).

THE organising committee with reference to the forthcoming Electrical Exhibition is now complete. At a meeting held on Monday, Jan. 20th, in the Electricity Committee Room at the Town Hall, Manchester, Councillor Kay, J.P., of Manchester, was elected chairman of the committee, and Councillor Barratt, of Salford, deputy chairman.

The secretary gave a full report of the scheme as existing up to date, and it was unanimously decided to put the same into effect, and to enter into the necessary arrangements for holding the Exhibition in Manchester next October. In order that matters should be dealt with promptly, an executive committee was appointed consisting of the following gentlemen:—The chairman, the deputy-chairman, the consulting engineers, Messrs. Pearce & MacCowan, Messrs. H. Berry, H. Bevis, D. N. Dunlop, E. Nalder, C. D. Taite, and H. Talbot.

In order that the committee may be able to decide definitely as to the size of the buildings which it is immediately necessary to place the contract for, it was decided to send out a preliminary circular to the trade, asking for an indication as to space required by various exhibitors, and the design of the buildings will be such that extensions can readily be effected up to within three months of the date of opening.

Large numbers of applications have already been received from the principal electrical and engineering firms throughout the country, and it is hoped that all those likely to be interested will assist the committee in concluding their final arrangements for this important exhibition, by dealing with the matter promptly and by getting into touch with the management at once.

LITERARY Section.

Including

Reviews of Books, List of Practical Works, Publishers' Notices, Standard Publications, WORLD'S ELECTRICAL LITERATURE, New Catalogues, &c.

Readers will find this Section invaluable. We shall be pleased to furnish further particulars regarding the Books dealt with herein, or to supply information concerning any other books. Communications requiring an answer through the post must be addressed to Literary Editor, THE ELECTRICAL MAGAZINE, *Bazaar Buildings, Drury Lane, London, W.C., and accompanied by stamped envelope.*

WORKS OF REFERENCE.

Hazell's Annual for 1908. EDITED BY WILLIAM PALMER, B.A. (LOND.) (LONDON: HAZELL, WATSON, & VINEY, LTD., 52, LONG ACRE, W.C. PRICE 3s. 6d. NET.)

This popular "Annual" maintains its great reputation with the 1908 edition. It is difficult to single out for mention any examples of the thousands of subjects dealt with: the remarkable feature is that so much information has been put together in such convenient order and can be obtained at such a low price. Its claim to be "the one book for the busy man in all ranks of life" is more than justified by the new (the twenty-third) volume. Those who have not the time to search through piles of Government publications and Blue Books for the latest information will find the gist of the principal Acts of Parliament summarized; on such questions as the Licensing Laws, Education, Finance, Old-Age Pensions, the Labour Movement, and many other subjects the latest information is supplied. A considerable number of new biographies appear, and it can be truly said to supply all that is necessary for the purposes of historic record of the past year, and at the same time give the reader just those points necessary for use by way of reference during the present.

Daily Mail Year-Book, 1908. EDITED BY PERCY L. PARKER. (LONDON: THE ASSOCIATED NEWSPAPERS, LTD. PRICE 6d. NET.)

This is the eighth year of publication of the "Year-Book." As set out in the Editorial Preface, "it seeks to give the essential facts of the chief questions of the day." The matter included covers an immense range, and will be be found, in one way or another, of constant use to everyone. The arrangement is by subdivision according to subject, there being eleven sections: Questions of the Day; Socialism; Travel and Traffic; Parliament and Politics; Personal; The Empire; Foreign Affairs; Religious, Educational; Commerce; Financial; Naval and Military.

Technical Dictionary in Six Languages. BY K. DEINHARDT AND A. SCHLOMANN. VOL. II. ELECTRICAL ENGINEERING, INCLUDING TELEGRAPHY AND TELEPHONY. EDITED BY CHAS. KINZBRUNNER. (LONDON: ARCHIBALD CONSTABLE & CO. LTD., 10, ORANGE STREET, LEICESTER SQUARE, W.C. PRICE 25s. NET.)

This dictionary is very complete, and is certain of recognition as a standard electrical work. Not only are single words expressed in the six languages—German, English, French, Russian, Italian, Spanish—but in some cases compound expressions or phrases are given. A further valuable feature is the frequent use of a small illustration or diagram to assist the translation. The present volume includes upwards of 2000 pages of matter, and has about 4000 illustrations. The lengthy list of eminent electrical men who have, as contributors and revisers for their respective languages and sections, assisted in the preparation of the work vouches for its accuracy.

Willing's Press Guide AND ADVERTISER'S DIRECTORY AND HANDBOOK, 1908. (LONDON: JAMES WILLING, JUNR., 125, STRAND, W.C. PRICE 1s.)

This is the thirty-fifth year of "Willing's Guide," which is, in these days of universal advertising, more than ever indispensable to the business man. It is a complete index to the newspapers, magazines, and all periodical publications issued in the United Kingdom, giving full particulars of their time and place of publication, price, and special features. There is a further similar list of the principal colonial and foreign journals. In addition, there is much interesting information as to the history of well-known newspapers, and a valuable classification of interests, professions, trades, religious denominations, scientific subjects, &c., with their Press representatives. The work is remarkably cheap, and should be taken up as an essential by the commercial man.

Approved Electrical Fittings. Electrocraft Illustrated List of Approved Electrical Fittings and Revised National Electrical Code, Illustrated. (Michigan, U.S.A. : Electrocraft Publishing Company, Detroit. Price 50 Cents.)

The title explains the nature of this work. It is published as a semi-annual, and is claimed to be the only complete illustrated list of the electrical fittings approved by the Underwriters' Association, U.S.A., and that it is in constant use not only by the entire electrical field, but by many of the large manufacturing corporations of the United States. It has become a standard reference book with practically all American buyers and users of electrical fittings, and in this connection it will be found also of considerable value in this country, since it forms a unique compilation of every type of detail and accessory used in electric lighting, fitting and wiring service.

Sell's Directory of Registered Telegraphic Addresses, and National List of Large Commercial Houses. (London : Henry Sell, 166, Fleet Street, E.C. Price (including three supplements, issued quarterly) 21s.)

The continual increase in telegraph business adds to the usefulness of this well-known directory, and it has further come to be recognised as a general guide to the 70,000 leading firms of the United Kingdom.

The chief alphabetical section is divided into London and Provincial for ready reference. Then there is no intermingling of small firms and private people, as the names only of possessors of registered telegraphic addresses are given. This is done in good, clear type, together with the details of trade or profession, full postal and telegraphic addresses, and telephone numbers. This last particular will specially appeal to those who are often using the telephone for localities outside their own district.

Another important feature is Section III., which gives all the names of the firms classified by their trades. This enables immediate reference to the larger houses in any branch of business.

This edition shows a great improvement and extension in the list of leading colonial and foreign firms, which was included last year for the first time. This will be found a great boon in cabling, circularizing, &c. Being arranged alphabetically by countries and then by towns, ready reference can be made to any part of the world.

The following special articles of commercial interest are also included :—The World's Industries in 1907, exhaustive postal information, the Post Office in 1907, charges for cables the world over, and a list of our Consuls in foreign countries classified under the towns in which they are resident.

To those doing even an ordinary amount of business this book must be most useful, but to large firms it is indispensable. The addresses are from official lists supplied by the authority of the Postmaster-General, and each three months supplements are issued free to subscribers, thus advising them of the latest alterations, additions, &c.

A Technological and Scientific Dictionary. Edited by G. F. Goodchild, M.A. (Camb.), B.Sc. (Lond.), Principal of the Wandsworth Technical Institute, and C. F. Tweney, Late Librarian and Secretary, Putney Public Library. (London : The Electrical Publishing Company, Ltd., Bazaar Buildings, Drury Lane, W.C. Price cloth 18s. 6d., half morocco 21s. net.)

This is an extremely valuable book which should meet with a great demand from engineers and practical men generally. It is more than a mere collection of definitions—approaching nearer to the form of an encyclopædia, but having the important difference that the series of articles and illustrations included have all been contributed by experts and with a view to keeping the matter always concise and to the point. The result is that the material has been assembled in a single volume of quite a reasonable and not unwieldy size. In the advertising pages of The Electrical Magazine will be found full details of the many scientific and industrial subjects covered, and a list of the more prominent contributors. The book can be obtained on the instalment system—an advantage which will doubtless appeal to many who are desirous of possessing a really accurate and complete reference dictionary.

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Electric Arc Lamps. Their Principles, Construction and Working. By J. Zeidler and J. Lustgarten, M.Sc. (London: Harper and Brothers, 45, Albemarle Street, W. Price 5s. net.)

There has, since the earliest use of electricity as lighting agent, always been much rivalry in the arc-lamp field. Their manufacture has been taken up by practically every electrical firm having a workshop, and at the present time, with the introduction of more advanced principles, the competition of maker and designer is more keen and widespread than ever. There is no doubt therefore that this book will have a wide circulation, since it covers its subject in a very complete degree. All the more noteworthy lamps are described in detail, are well illustrated, and criticised. The principles of the arc are treated theoretically, and the manufacture of lamps is also dealt with. In turn the following branches of the subject are treated: The electric arc—open, enclosed, alternating and flame types; the principles of arc lamps—series, shunt and differential; the construction of arc lamps, with co-axial carbons and open arcs, flame lamps, enclosed lamps; light intensity and distribution, the practical application of the arc to illumination; the arrangement of arc lamp installations and accessories. In addition there are appendices giving information of photometric quantities, costs of lighting, and photometric rules, &c. In this combining of the theory and practice of illumination by arc into one volume the book is unique. It is excellently produced and arranged. Every student and worker in the electric lighting field should secure a copy of what is indeed a remarkably cheap and complete treatise of its subject.

Airships, Past and Present. By A. Hildebrandt, Captain and Instructor in the Prussian Balloon Corps. Translated by W. H. Story. (London: Archibald Constable & Co., Ltd., 10, Orange Street, Leicester Square, W.C. Price 10s. 6d. net.)

Who is there to-day not interested in the conquest of the air? The names of Dumont, brothers Wright, Farman have quite a fascination for most of us; there are innumerable scientists and others engaged in more or less elaborate experiments with aeroplanes and propellers. Romance and science run together whenever flying machines are spoken of; and it is so in this praiseworthy translation of the story of man's efforts to fly as written by a Prussian balloonist.

The opening chapter, devoted to the early history of the art, cites the wonderful legends and myths of undated history, and brings one forward by strange and frequently amusing stages of effort, rather than development, to the recent times of the eighteenth century. The first parachute descent was made in 1771. Hydrogen gas was discovered in 1776, and about this time it became generally understood that light gases or rarefied air presented great possibilities. It seems that to the French nation belongs the credit of the discovery of ballooning; the first public exhibition was given in that country on June 5th, 1783, when a paper balloon 112ft. in circumference was sent up to a height of 1000ft. with hot air as the lifting gas. The brothers Montgolfier were the inventors, and as such they were loaded with presents and honours. The history of ballooning makes a most entertaining story, and the book loses none of its interest when it passes to the theory of the subject and the practical utility of the balloon of present times.

The work done with dirigible balloons is entered into very fully, and, of course, flying machines and aeroplanes receive the closest attention. There is, indeed, so much in this book that an adequate review of its contents would run to considerable length. It is necessary, however, to point out that this is, after all, a practical guide to aerial navigation; military ballooning and the methods of signalling, photography, meteorology, &c., are discussed in detail; even the construction of balloons and flying machines occupies quite a considerable space in a book which is in every way to be recommended as perfect of its kind.

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International Electrotechnical Commission.

The following is a list of the members of the British Electrotechnical Committee as re-appointed by the Council of the Institution of Electrical Engineers for the year 1908. The Committee is about to take up the question of "Symbols," and a sub-committee has been appointed to deal with the matter with a view to international agreement.

Sir John Gavey, C.B., president.
Colonel R. E. Crompton, C.B.
Mr. W. Duddell, F.R.S.
Mr. Kenelm Edgcumbe.
Dr. Gisbert Kapp.
Dr. R. T. Glazebrook, F.R.S.
Mr. R. Kaye Gray.
Mr. Robert Hammond.
Colonel H. C. L. Holden, F.R.S.
Mr. T. Mather.
Mr. H. W. Miller.
Prof. J. Perry.
Sir Wm. H. Preece, K.C.B., F.R.S.
The Rt. Hon. Lord Rayleigh, O.M., F.R.S.
Mr. Alex. Siemens.
Mr. C. P. Sparks.
Mr. J. Swinburne, F.R.S.
Prof. S. P. Thompson, F.R.S.
Mr. A. P. Trotter.
Mr. E. B. Vignoles.
Mr. C. H. Wordingham.
Mr. G. C. Lloyd, honorary secretary.
Mr. C. le Maistre, secretary.

New Catalogues

Telephones, &c.—The General Electric Company, Ltd., London, E.C.—The 10th edition of this telephone catalogue embraces telephone apparatus for all purposes, and includes among other items domestic telephones for fitting on existing bell circuit, battery call wall and table telephones for offices, warehouses, hotels, &c.; intercommunication wall and table telephones, including the "S.R." self-replacing telephone, an ideal telephone for offices, &c., the "S.S." secret service telephone, an intercommunication system which ensures absolute privacy of conversation between stations connected; the "Reply and Call" system, especially useful where it is undesirable for offices connected to speak to each other except by pre-arrangement with the manager, who can control and overhear all conversation.

Magneto call telephones for short and long distances are listed in a variety of types and designs for various purposes; watertight telephones, battery and magneto call, for mining, ships, and engine house use; rifle range telephones and specialities; military telephones, traction telephones and switchboards for battery and magneto call are also fully described and illustrated.

A complete line of central battery wall and table telephones is also included, and special attention should be paid to the all-steel cases and enamelled wall telephone illustrated on page 1545, which is certainly the neatest central battery wall telephone on the market and an ideal set for fitting in hotels, offices, and private residences.

Central battery switchboard construction also claims this company's attention, and in the designing of the switchboards illustrated on pages 1567 to 1572, the important features of efficiency and pleasing appearance have evidently had the serious consideration of the company's engineers. We understand that the company is now prepared to manufacture and instal complete equipments for central battery exchanges of any capacity in any part of the world.

The "Phone-Eze" telephone bracket is another of the specialities for which this company is finding a ready sale. It is illustrated on page 1548, and, used with central battery desk telephones as described on the previous page, is an extremely convenient device for keeping the desk clear of the telephone, whilst retaining it within reach for immediate use.

The catalogue also includes a complete list of fire alarm apparatus, amongst which is a very useful thermostatic heat detector, the invention of Lieut.-Col. Fox, of the London Salvage Corps, which can be fitted up in conjunction with existing electric bell circuits.

Water-level indicators, electric self-winding and regulator clocks and watchmen's tell-tales are also to be found in this interesting catalogue.

A comprehensive alphabetical index and telegraphic code are to be found at the end of the list.

We understand also that loose sheets of the pages in the catalogue are also stocked, so that an illustrated description can always be forwarded to a customer without mutilating the catalogue. These catalogues are issued post-free to the trade only on receipt of trade card.

Pulley Blocks, Travellers, &c.—The Mork Patent Pulley Block Co., London.—Publication E. 1908 is described as an illustrated catalogue of high-class lifting tackle and cranes. It is a well-produced little book which gives quite a good deal of information. The specialities listed include pulley blocks for rope and chain, electric travellers, wall crabs, cranes, winches, overhead runways, and chains. This firm makes a special feature of chain-making, and also caters for the work of periodical annealing of lifting chains in compliance with the Factory and Workshop Act.

Electric Heaters.—The Phœnix Electric Heating Co., Ltd., London. — The catalogue issued by this company extends to nearly 150 pages, and illustrates about as many types of electric heating, cooking, domestic and industrial appliances. Every central station man should have a copy of this book; he will find some article listed which will appeal to every one of his consumers.

Gas Plants.—Hopkinson Gas Plant Co., Huddersfield.—List No. 150 gives illustrated particulars and specifications of suction, suction pressure, and pressure gas plants as made by this company for use with coke, anthracite, charcoal, &c. The firm also make other producers suitable for bituminous coal, and other fuels such as wood, lignite, and peat. The particular claims advanced for these plants are that they are designed to give the best efficiency, and that they are essentially simple and automatic in action. The catalogue gives a large amount of interesting data as to the performance, dimensions, weights, and prices of the plants, and should be in the hands of every power engineer.

Bitumen Cables. — Johnson & Phillips, Ltd., Charlton, Kent. — An illustrated price list dealing with Paterson's Vulcanised Bitumen Cables. Twelve different classes of these cables are listed, ranging from single-core, taped up to those of the three-core double-armoured type. Jointing materials and accessories are included; also illustrations of bitumen-sheathed, paper-insulated cables for high-tension work, and of the 6600 volt bitumen cables supplied for the London, Brighton and South Coast Railway electrification scheme.

Engineering Specialities.—Michael Pal & Co., London, S.W.—The catalogue bearing this title deals in picture and text with many dissimilar machines. Thus we have in rotation descriptions of waste cleaning plants, turbines, fans, blowers, pumps, electro-magnetic lamp, drain valve, lubricator, oil engines, gas engines and producers, dynamos and motors.

Trade Notices.

Balchin, Schulz & Co.—Mr. H. A. Balchin, F.C.I.S., and Mr. G. F. Schulz, who were secretary and chief inspecting engineer respectively to the Alliance Electrical Company, Ltd., for seven years, have recently joined partnership under the above title, to carry on the business of electrical and general engineers and contractors. The address of Balchin, Schulz, & Co., is Lennox House, Norfolk Street, Strand, W.C.

Rhodes Motors, Ltd., have appointed Mr. Frank Parkinson as their representative for the Yorkshire District. Mr Parkinson's temporary address is Eldon Mount, Guiseley, near Leeds.

The World's ELECTRICAL LITERATURE

You should carefully study this page, as it will save you much valuable time. It is the key to the World's Monthly Electric Progress. We can supply the publications mentioned, or any article indexed, for a small fee. In writing us, enclose stamped P.C. for reply.

Power.

Power Development on the Chicago Drainage Canal.	*Westn. Electn.*, 4/1/08.
Light, Heat, and Power Development in Salt Lake City, Utah.	*Westn. Electn.*, 4/1/08.
Electrical Machinery used in Coal and Coke Operations. W. B. Spellmire.	*Westn. Electn.*, 21/12/07.
Natural Gas *versus* Electricity. J. T. Huntington.	*Westn. Electn.*, 21/12/07
Electric Power in Rolling Mills.	*Stahl u. Eisen*, 18/12/07.
A large Coal Dock with Remote-Controlled Induction Motors.	*Elec. World*, 11/1/08.
Wiring for Direct-Current and Alternating-Current Motors. L. J. Auerbacher.	*Elec. World*, 7/12/07.
Portable German and English Electric Drills on Trucks. F. C. Perkins.	*Amer. Mach.*, 25/1/08.
Novel Electric Drive for Rolling Mills.	*Amer. Mach.*, 25/1/08.
Friction and Lubrication. J. T. Nicholson.	*Amer. Mach.*, 25/1/08.
Electricity in the Textile Trade. E. L. Hill.	*Elec. Engng.*, 30/1/08.
Largest Gas Engines for Electrical Work. C. P. Poole.	*Power*, 21/1/08.
Rolling Mills and Winding Engines Operated by Thury Motors.	*Elec. Rev.*, 24/1/08.

Traction and Transport.

Electro-pneumatic Train-movement Control at the Junction of Three Railroads in Chicago.	*Westn. Electn.*, 21/12/07.
Misoxer Valley Railway (1500-volt d.c.). S. Herzog.	*Elek. u. Masch.*, 8/12/07.
Electric Motor-cars. W. A. T. Mueller.	*Elek. Zeit.*, 19/12/07.
Reinforced Concrete Railway Viaducts at Seville, Spain. E. Ommelange.	*Railroad. Gaz.*, 17/1/08.
A New Method of Supporting Overhead Conductors.	*Elec. Rev.*, 24/1/08.
Track Reconstruction in San Francisco.	*Str. Rly. Journal*, 18/1/08.
The Permanent Way. H. L. Weber.	*Str. Rly. Journal*, 18/1/08.

Central Station.

Ratio of Heating Surface to Grate Surface as a Factor in Power Plant Design. W. S. Finlay.	*Westn. Electn.*, 21/12/07.
Temperature Rise of Conductors. C. C. Badeau.	*Elec. World*, 11/1/08.
Substation Switchgear. W. Pleasance.	*Elec. Rev.*, 24/1/08.
The Design of Pre-payment Watt-hour Meters. A. Pestel.	*Elec. World*, 18/1/08.
The Tantalum Lamp in Central Station Service at Muncie, Ind. G. C. Osborne.	*Elec. World*, 18/1/08.

Lighting and Heating.

Metallic Filament Lamps and Incandescent Gas Lamps.	*Journ. f. Gasbel*, 9/11/07.
Resistance Heating (Kryptol).	*L'Ind. Elec.*, 10/12/07.
Inverted Arc Lamps for Press Room Lighting.	*Elec. World*, 11/1/08.
Characteristics of the Magnetite Arc. G. M. Dyott.	*Elec. World*, 7/12/07.
Street Lighting by Tungsten Lamps.	*Westn. Electn.*, 18/1/08.

Design and Manufacturing.

Modern Cable Construction. F. C. Perkins.	*Electrocraft*, Jan./08.
A Deflection Photometer for Voltmeter Testing. H. B. Brooks.	*Elec. World*, 11/1/08.
Constant Current Dynamo. E. Rosenberg.	*Elek. Zeit.*, 19/12/07.
Torque Analysis of Induction Meters. A. R. Dennington.	*Elec. World*, 21/12/07.
Direct-Current Motors: Their Action and Control. F. B. Crocker and M. Arendt.	*Elec. World*, 7/12/07.
Coil Insulation in Electrical Apparatus. J. A. Jacobs.	*Elec. World*, 7/12/07.
The Hopkinson Test as Applied to Large Induction Motors. N. Pensabene-Perez	*Elec. Rev.*, 24/1/08.
Adjustable Water Resister. F. Ross.	*Elek. u. Masch.* 8/12/07.
Laboratory for Testing High Tension Porcelain Insulators.	*L'Ecl. Elec.*, 21/12/07.

Telegraphy and Telephony.

Long-distance Telephone Exchange Equipment. C. F. Saenger.	*Teleph.*, *Jan.*/08.
Wireless Telephony in the Navy (U.S.A.). N. J. Quirk.	*Teleph.*, *Jan.*/08
History of the Automatic Telephone. A. B. Smith.	*Sound Waves*. *Jan.*/08.
Wireless Telephones in Naval Service.	*West. Electn.*, 18/1/08.
Automatic Telephony. F. J. Truby.	*West. Electn.*, 18/1/08.
Telegraph Characters.	*Tel. Age*, 1/2/08.

Electro-Chemistry, Electro-Metallurgy, and Electro-Physics.

The Rolling of Thunder. D. S. Carpenter.	*Elec. World*, 21/12/07.
Ozone and the Regeneration of Air.	*Electrochem. and Met. Ind.*, *Jan.*/08
Gas-Electric Power at the Mansfield Copper Mines and Smelting Works.	*Electrochem. and Met. Ind.*, *Jan.*/08.
Chemical Analysis with Rotating Anodes in the Industrial Laboratory. A. M. Fairlie and A. J. Bone.	*Electrochem. and Met. Ind.*, *Jan.*/08.
Solenoid in Series with Resistance. C. R. Underhill.	*Elec. World*, 18/1 08.
Electro-thermic Production of Iron and Steel. J. W. Richards.	*Jour. Frank. Inst.*, *Dec.*/07.
Temperature-Resistivity Coefficient of Alloys. W. Guertler.	*Phys. Zeit.*, 1/1/08.
Electro-Analysis. F. Foerster.	*Zeit. f. Elek.*, 3/1/08.

(50th Issue.)

The Electrical Magazine.

FOUNDED AND EDITED BY
THEO. FEILDEN.

VOL. IX. No. 3. LONDON. MARCH 16th, 1908.

The World's Electric Progress.

Our Iron and Steel Number.

We have the preparation of our Iron and Steel number well advanced and there is every sign of its being a great success. The literary contents will include writings by experts in the manufacture and working of iron and steel and in the commercial management of these far-reaching national industries. Electrical engineers who have made a special study of the power requirements of blast furnace plants, rolling mills, &c., and who have themselves actually put down and operated such equipments, have contributed articles based upon their experience. It will be seen therefore that the April number of THE ELECTRICAL MAGAZINE is bound to be of particular service to every engineer. The man whose labour is amidst the heat and ceaseless ponderous activity of the great iron works is to be brought into line with up-to-date electrical practice so far as it affects him in particular; the electrical manufacturer and power engineer will be given in convenient form a collection of facts, complete and all-important when the electrification of iron-works is the job in hand.

Our readers can help us very greatly towards the perfection of this special number. Electrical manufacturers and those practical electrical men who have already put down equipments in iron and steel works are always in the best position for securing further work of that class—provided they see to it that the fact is published abroad amongst potential customers for similar classes of work. Let them therefore send us for publication those details of the work they have done, and the plant they make for such work, as will carry conviction and weight with the iron and steel engineer.

Similarly those firms who deal in the many grades and forms of machines, machine-tools and auxiliary plant required in the recovery and working of iron and steel in bulk, will find it to their advantage to indicate how such machines and plant are designed for and can be driven readily by electrical power. They must know by now that the electric motor is *the* driving end of all moving plant to-day; the user of plant has declared emphatically for electric power and business will come to the man whose machines are best suited to the electrical drive.

The important feature to remember is that the Iron and Steel Number of THE ELECTRICAL MAGAZINE is entirely special in its character; it is certain of a very wide circulation amongst owners and workers in the great iron and steel centres. Our experience with the Colliery and the Textile numbers of this journal, which were published last year, and for which there is still a steady demand, proves the great popularity and evident value of our "Industrial Series." The Iron and Steel number, the third of the series, will, we hope, surpass the gratifying results achieved by its two forerunners; it will stand unique as a means of bringing the electrical engineer and his confrère of the iron industry into close touch with each other.

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Festivity and Protection.

It is well known in electrical circles that when the General Electric Company undertakes the entertainment of its friends the Company's reputation for thoroughness is more than upheld. The eighteenth annual dinner, which recently took place at the Trocadero, did not disappoint any one of the hundreds of guests who have come to look upon this gathering as one of the most enjoyable of its kind. The G.E.C. festival is quite a red-letter day in the annals of many electrical men; on this occasion one always meets old friends, and one finds electrical men of every sphere of the industry—professorial, practical, and commercial—assembled round the festive board.

A particularly happy feature of the event was the presence in the chair of Mr. Gustav Byng, the popular chairman of the company, whose restoration to health and activity after a long illness evoked a general expression of gratification in which we cordially join.

There were very many of the leading lights of the electrical world present, and, of course, there were words of wisdom in the post-prandial speeches—for the engineer when discoursing to his fellows, even after dinner, cannot help but be more or less technical. In this case the Chairman, starting with a eulogy of the wondrous metallic filament lamp, passed to the other extremity of the electrical system and introduced large turbo-generators. "Everything electrical" has always been the catchword of the G.E.C., and in thus marking the Company's progress on the small and large products, the great extent of the present-day business and the enterprise of this go-ahead British firm, Mr. Byng proved how closely they were bent on following their motto to the letter. Yet despite the good development of the Company, the speaker, than whom no one is better qualified to judge, felt it necessary to denounce the attitude of the Government as being all against the industrial progress of this country. Comparing the state of our electrical manufacturing concerns with those of other nations, Mr. Byng whole-heartedly and emphatically deplored the continuance of the Free Trade policy. The State does nothing for the home manufacturer—in other countries, State-aided by Protection, electrical manufacture has progressed far beyond us. We cannot report this spirited speech in full, but it is worthy of particular note when we find the chairman of one of the greatest of our British industrial concerns declaring himself entirely and absolutely in favour of Tariff Reform. We have ourselves frequently written on this all-important national subject, and need hardly repeat that we support Mr. Gustav Byng's contention. This question is not a political or party one, it is too closely connected with our national vitality, and as such it requires that every industrial and technical journal shall spare no effort towards forwarding the cause of a change essential to the well-being of British manufacture.

There were several other interesting and entertaining speeches—notably those of Colonel R. E. Crompton, Mr. W. M. Mordey and Professor John Perry. Colonel Crompton commended the work of electrical journals in pressing forward controversial subjects; as for Protection, he, as chairman of a public supply company, felt that he might need it for some little time to come, now that metallic filament lamps were here.

Mr. Mordey touched also upon matters of public supply, urging the necessity of central station men making a dead-set for the small consumer's custom, and indicating the great business which the gas supply with its penny-in-the-slot trade enjoys.

That the metallic filament lamp has proved the salvation of electric lighting is the opinion of Professor Perry, as expressed in a humorous speech which, tending in general as it did towards the benefits of gas, gives the speaker's praise of the new electric lamp an additional value. The Professor referred with sympathy to the illness of Mrs. Ayrton and to the continued ill-health of Professor Ayrton, who had been unable to attend the dinner.

Mr. Hugo Hirst, the managing director of the company, had kindly praises to tender to his able staff and colleagues. To him fell the duty of proposing "Our Friends"; in response Mr. E. Grant Burls not only said words in praise of the G.E.C., but also asked a very pointed question which we can very well leave with our readers to think about: "Why is it that men who rigidly protect their work refuse to protect the product of that work?"

* * *

Trade and Industry.

There is no keener advocate of the policy of Tariff Reform, Protection, Preference—call it what one will—than Mr. Hugo Hirst, who, as Managing Director of the General Electric Company, has one of the largest manufacturing engineering concerns of this country in his keeping. Mr. Hirst presented a noteworthy paper opening a recent debate at the "Compatriots" Club on "Some Business Aspects of Tariff Reform." The paper gives clear comparisons between "trade" and "industry" and between the manufacturer and the merchant. The author says:

> Loose ways of speaking are almost always an index to loose ways of thinking. People have got into the way of coupling "trade" and "industry" as if they were convertible propositions. But they are nothing of the kind. As a matter of fact, good "trade" may very conceivably be the absolute enemy of "industry."
>
> The interests of a manufacturer and of a mere merchant are diametrically opposed to each other. A manufacturer invests his capital in the country in which he carries on business, in the shape of land, buildings, of a plant of machinery, and so forth. He then becomes a considerable ratepayer. It is, of course, to his interest that the district round his factory should be well populated, and his interest, putting the matter on the lowest ground, prompts him to have a care for the moral and social well-being of this community.
>
> A manufacturer, by the necessities of his position, promotes good citizenship.

Mr. Hirst quotes his position as a manufacturer, mentioning the thousands of hands employed by his company, the large capital sunk in works and in the erection of workers' dwellings, churches, schools, &c. In fact the manufacturer has in this case created a small town, whose social and economic welfare is essentially a matter of his concern. Its people are mainly his workers, and it is to his interest that they have conditions and facilities afforded for the enjoyment of happy, industrious life. In this town of the manufacturer the people, too, are ever in sympathy with the works' progress and the interests of the manufacturer.

After thus picturing the work of his Company as a manufacturing concern, the author makes a direct comparison with those who are solely merchants or traders, and whose competition under the present Free Trade *régime* is the great factor which curbs the proper and full development of home industry. Speaking of the merchant, Mr. Hirst says:

> His trade, looked at in the light of Board of Trade returns, may be quite as important as ours. It might possibly be larger, but how far has his trade contributed to the prosperity of this country? He has invested no capital in this land; he has built no factories to benefit British working men; he is carrying goods under the cheapest flag, be it German, French, American, or British, so long as he gets the cheapest freight; he has no need for large warehouses, because he need not keep much stock in this country; he has a staff of some dozen assistants, fifty at the outside. Amongst them are not many British, as he prefers to employ clerks speaking the language of the country in which his commodities are produced. To him it is all one whether the goods he deals in are Japanese, Chinese, German, or American. Briefly his interests are so cosmopolitan that all barriers between one country and another are hindrances to him. His aim is to reduce the economic walls which have been built up between nations, and to have one wall less he might sacrifice the best interest of this country.

ELECTRO-MAGNETIC ABSORPTION DYNAMOMETERS.

PROBABLY the nearest approach to an ideal absorption dynamometer is to be found in the dynamo supported in a cradle. The generated power is absorbed in the production of electric currents so that there is no danger of seizing. The load is easily regulated by the turning of a rheostat arm. The principal objection, however, is the difficulty of absorbing the current. This is particularly true for the absorption of large currents. Practically the only available means are banks of lamps and water rheostats, both of which are cumbersome, occupy valuable space, and require considerable attention. Writing in a recent number of *The American Machinist*, C. M. Garland reviews the principles of the common forms of dynamometer, and gives details of a new type devised by himself.

The new dynamometer is the result of an attempt to meet the demand of testing laboratories and engine builders for a satisfactory means of absorbing the power given out by engines and motors under test. At the present time the devices used for this purpose are numerous and vary from a 2 by 4 scantling with one end under the fly-wheel and a workman on the other, to a dynamo producing current. Between these extremes fall the well-known Prony brake, the Alden brake, the fan blower and the water wheel, all of which labour under more or less serious practical disadvantages.

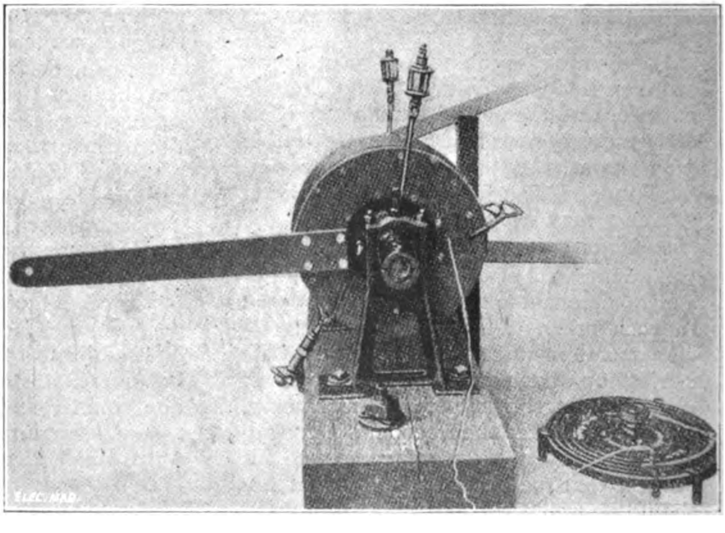

FIG. 1. THE GARLAND DYNAMOMETER.

The difficulties attending the use of those types of brakes which depend upon mechanical friction for the absorption of power are well known. They are more or less inconvenient and untidy in use and there is always a tendency in the brake to bind or "seize," due to a change of temperature, to a change of the water supply, or to a change in the pressure between the friction surfaces from an increase in the load. This tendency of the brake renders the regulation of the load for smooth running exceedingly difficult, and, in the case of high speeds, such as are found in steam-turbine practice, renders the use of this type of brake even dangerous, as any "seizing" at these speeds may result in the failure of a coupling or the tearing loose of the rotating mass from the supporting shaft.

The fan-blower and water-wheel have not been used to a very great extent for the absorption of power. While they have not the disadvantages named above, there are

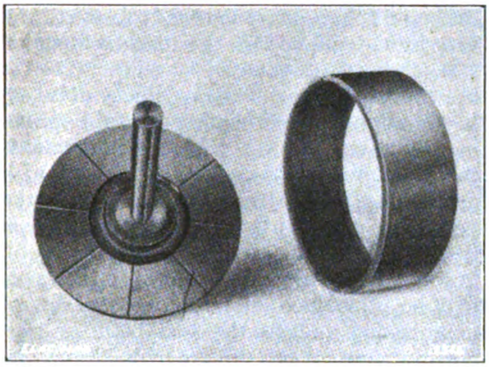

Fig. 2. Armature and Casing.

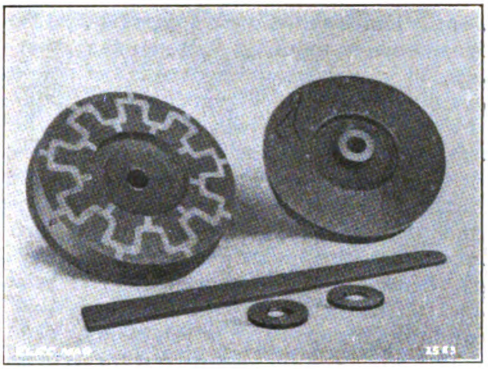

Fig. 3. Field Magnets and Smaller Parts.

other objections to their use which are just as serious, such as the difficulties in varying the load or the speed and the large size required for large powers.

The Garland type of dynamometer is in use in the mechanical engineering laboratory of the University of Illinois. It depends for its operation upon the fact that eddy currents are induced in a conductor revolving in a magnetic field of varying density. The reaction between the eddy currents and the field that produces them develops a torque similar to that produced between the rotor and stator of an induction motor. The heating effect of the eddy currents is carried off by the cooling water.

In construction the apparatus consists simply of a soft-steel disc securely keyed to a shaft and revolving between two large field magnets. The construction of the magnets is such as to produce a field of varying magnetic density. The armature and pole-pieces are enclosed in a water-tight casing, and means are provided for the circulation of water around

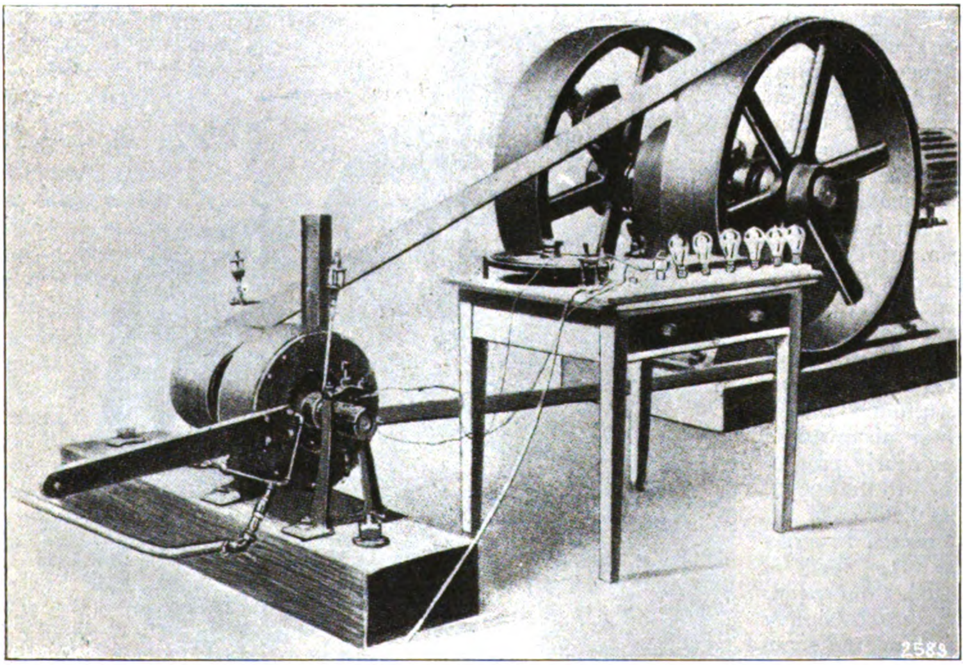

Fig. 4. The Garland Dynamometer belted to Engine.

them. Fig. 1 shows a side elevation of the dynamometer mounted in temporary bearings. Fig. 4 shows the dynamometer belted to a 60h.p. engine. Fig. 2 shows the armature and casing. It will be seen that the armature is provided with radial grooves for the circulating water. This water enters through the field castings on each side of the armature near the centre, and is thrown out through the radial grooves and the air-gap between the armature and the pole faces. It is then led to waste by a connection through the bottom of the casing.

Fig. 3 shows the assembled fields, the weighing arm and the end-thrust collars. The fields are made up of three pieces—the field casting, containing an annular recess for the field coil; bearings for the driving shaft and two intermeshing radial pole pieces which are held together and made water-tight by having lead cast in the interstices around the radial poles. The pole pieces are bolted to the field casting, and completely enclose the field coil. While the armature is practically balanced between the two fields, brass bearing rings are provided to prevent the armature from rubbing the pole faces, and to take care of any unbalanced end-thrust that may be caused by a slight difference in the air-gaps on either side of the armature.

This machine is 17in. in diameter, occupies 9in. on the shaft, and at a speed of 1800r.p.m. absorbs 34h.p. From recent tests it has been found that the power absorbed is very nearly proportional to the speed. The field coils are connected in series and the load is varied from 2h.p. to 34h.p. by simply adjusting the rheostat. The load remains practically constant; there is no tendency to seize, and very little tendency for the load to fluctuate with changes in quantity or temperature of the cooling water. The machine is noiseless in operation and entirely free from the splashing of water and oil. In the illustrations the dynamometer is shown equipped with a weighing arm. In order to measure the power, the force at the end of this arm must be weighed. This particular arrangement, however, is not necessary. A spring balance may be connected directly to the casing or field casting and to the bed plate or supporting frame, or the machine may be calibrated for given amounts of exciting current, and, instead of weighing the load, measurements of the current flowing through the field are taken by ammeter. Then, from curves showing the relation between exciting currents, speed and horse-power, the power absorbed may be obtained without calculation. There is one disadvantage in this machine; that is, for slow speeds it is hardly practicable to build the dynamometer sufficiently large to absorb the power given

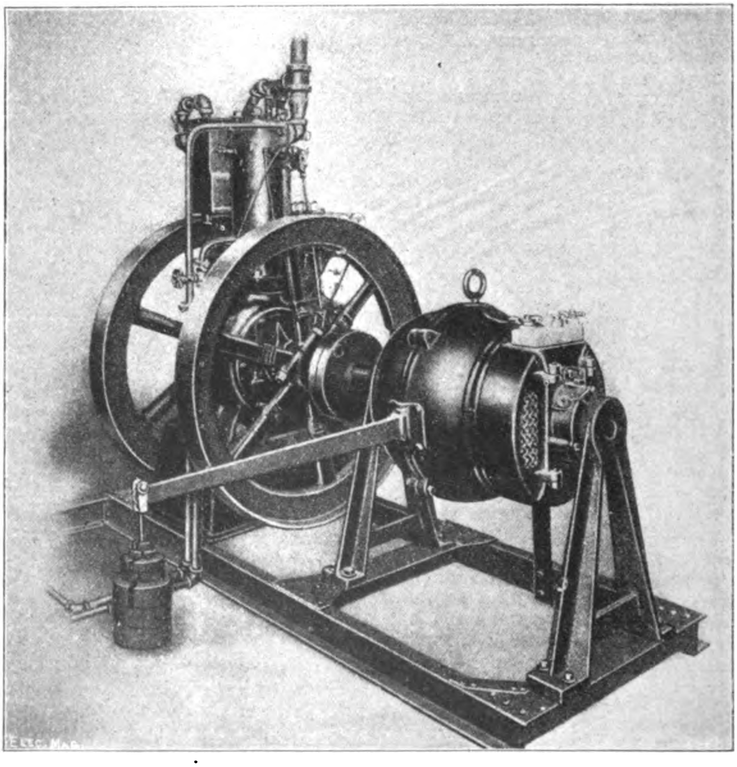

Fig. 5. The Sprague Dynamometer.

out when direct connected. Thus, belting or gearing must be resorted to. For speeds above 1000r.p.m. it is entirely practicable to build the machine so that it may be direct connected to the engine or motor to be tested.

Another dynamometer of the electric absorption type, as manufactured by the Sprague Electric Company, is shown in Fig. 5. This dynamometer is constructed for testing engines varying in size from 1h.p. to 10h.p., and is intended for giving instantaneous values of the brake horse-power of any engine, motor, pump, or other tool which may be placed upon the testing frame. The principle made use of is the magnetic reaction set up between the armature and field of a dynamo. The machine to be tested is lined up with the armature-shaft of the generator and attached thereto, and when set in motion drives the armature in the usual way. The generator frame is carried on trunnions mounted in ball bearings, which allow the field magnets to move concentrically with the armature. The reaction set up when the latter is delivering current tends to drag the field frame around in the same direction of rotation, but this drag is balanced by means of weights placed on an arm bolted to the field frame. The load is varied by varying the output of the generator, which may be done by varying the absorbing resistance or by adjusting the field excitation. When a balance is secured the weight on the lever arm is noted, the speed of the engine is observed, and a calibration curve gives immediately without any calculation the horse-power output of the engine. The operation, as will be seen, is so simple that any mechanic may conduct power tests accurately and without difficulty.

The dynamometer may be used for observing instantaneous values of the output of the engine or for operating the latter for a running test on load. The design of the generator of the dynamometer is such that it will deliver a definite rated output continuously without excessive heating. The machine illustrated is rated for continuous operation at 10h.p. When a lengthy test of an engine on load is being conducted the output of the dynamometer may, if thought desirable, be utilized to good purpose as, for instance, it may be delivered to the lighting or power circuits of the shop, thus saving the energy which might otherwise be lost.

Pumping Plants for Floating Docks.[*]

THE amount of work done when lifting a ship is in direct proportion to the weight of vessel lifted; the larger and heavier the ship, the more water has to be removed from the dock within the limits of its lifting power. In most of the different types of floating dock, a main pipe of varying diameter runs from end to end of the dock at the bottom of the side walls. On this pipe the sea connections for the inlet valves and the branches for the distributing pipes are placed as may be required. To give the dock the requisite stability when working, the pontoons and walls are subdivided into a number of separate watertight divisions, each having its own flooding and draining pipe and air pipe. Flooding or draining goes on through the same pipe in each compartment, so that one set of pipes only is required for this purpose.

The pumps are usually of the centrifugal vertical spindle type, and are seated directly on to the main drain, taking water from the under side and discharging it at their own level into the sea. The motors for driving the pumps may be either steam or electric, and are generally placed on the top deck of the side wall. The connection between the pump and motor is by vertical shafting, supported at intervals by plummer blocks attached to the internal framing of the dock's wall. The weight of the shafting and pump impeller is carried by a ball thrust bearing in the motor bedplate. The engaging clutch between the motor and shafting is made flexible, to deaden noise and shock.

In steam-driven docks the engines are of the horizontal type with vertical crank shaft, simple high-pressure engines for low powers, and right-angled or tandem compound engines for high powers. When cheap electric power is available, it is undoubtedly the best that can be adopted, especially for "off-shore" docks, thereby dispensing with the weight of boilers, &c., on the dock and also reducing the number of permanent staff required for the dock. In manipulating the dock, the various valves are controlled from one central station. From each compartment valve in the bottom of the wall, vertica rods are led up to, and attached by a knuckle joint, to one arm of a crank; the other arm of the crank is attached to a horizontal rod, which is suitably supported at intervals close under the top deck by guide rollers, and led to the centre of the dock, where it is attached to another crank. From this crank a rod terminating with a rack is led up into the valve house. This rack engages a pinion, which is actuated by an ordinary hand wheel with spokes, similar to a steering wheel. In some instances, where there are a large number of different compartments in a dock, it is found convenient to group several compartments together, so that the number of wheels in the valve house shall not be excessive.

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[*] From a paper entitled "Floating Docks" read by Harry R. Jarvis before the North-East Coast Institution of Engineers and Shipbuilders, January 10th, 1908.

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High-Efficiency Lamps on the Continent.

Some interesting particulars of the progress made in the use of the modern flame-arc and metallic filament lamps in Continental towns are given by L. J. Auerbacher in a recent number of *The Electrical World.*

The town of Kaiserslautern, Germany, with a population of 55,000, has its principal streets lighted by alternating-current flame lamps. The lamps are so suspended from cables as to hang in the middle of the street and are swung 30ft. high and from 150ft. to 300ft. apart. The illumination even at these long distances apart is excellent. The lamps take 650 watts each. The cost for a year of 3000 hours is stated to be £19. Coal is 14s. 6d. per ton, but labour is cheap, firemen receiving 4s. per day, engineers 8s. per day, and the general superintendent £230 per year.

The alternating-current flame arc is found to work best with an initial voltage of 65 volts and a resistance to cut this down to 55 volts at the arc. With only 55 volts at the terminals much unsteadiness is caused. They are also operated well two in series on 110 to 120-volt circuits.

The plant, which is a municipal one, is in competition with a gas plant owned by private capital, which installs the latest type of inverted gas burners free of charge to customers. To meet this competition the electric people use the Osram lamp of 50 hefners (45c.p.), and use also many 100 hefner (90c.p.) frosted. Their load is now fully one-third Osram lamp. The lamps are sold to the customers at 3s. 6d. for the 50 hefner and 5s. for the 100 hefner, which includes a profit of 25 per cent. Experience with this lamp has been very satisfactory. The factory replaces lamps received in a damaged condition. The percentage of breakage is less than 5 per cent. If the lamp burns well for 50 hours, it is found that the life will continue to 800 or 1000 hours. Lamps that are blackened within 50 hours are replaced free of charge; discoloration is due to the material in the joint where the filament is made fast to the leading-in wires. The charge for electrical energy is 3.75d. per kw.-hour for the first 300 hours, and 1.25d. thereafter. The rates for power and light are identical. About 700kw. in motors and 1800kw. in lights are connected.

The Just wolfram lamps are also very largely used. They are now made for 16 hefners for 110 volts, and also 50 hefners for 220 volts. The factory replaces breakage, and their use is very general. As yet very few of the illuminating companies furnish free high-efficiency lamp renewals. The Strassburg plant is an exception, as it not only furnishes free tungsten lamp renewals, but will also instal the necessary wiring free provided a three-years' contract for current is made. The Strassburg company, which pays good dividends, is noted for its progressiveness.

Consumers are getting used to the larger illuminating unit of the metallic-filament lamp and the old 16 c.p. is falling into disfavour. In Paris the few shops still without the high c.p. tantalum lamp look as though they were out of business.

The large sewing-machine factory of G. M. Pfaff, at Kaiserslautern, uses 220-volt Just wolfram lamps and also Nernst lamps and flaming arcs. There are no low-efficiency lamps of any kind in the factory, which also employs the electric drive exclusively.

The Attention of Electrical Manufacturers is particularly directed to the great Iron and Steel Number of The Electrical Magazine to be Published April 15th.

Notes of important Iron and Steel Works equipments carried out by electrical firms and descriptions of electrical plant suitable for such work should be sent at once to the Editor.

SOME DEVELOPMENTS IN SYNCHRONOUS CONVERTERS.*

CHARLES W. STONE.

In this country (U.S.A.) the synchronous converter has become practically an indispensable piece of apparatus, some of the largest lighting and railway companies being entirely dependent upon it. Abroad the conditions are different, as the motor-generator has been used almost exclusively until within the last few years, when the motor-converter was introduced; as is well known, this machine being a compromise between the synchronous converter and the motor-generator.

It may be of interest to give at this time some idea of the increase in capacity of these machines in the last ten years on one of the large lighting systems, as this will give some idea of the tremendous development in machines of this type. In 1897, on the particular system in question, there was installed less than 1000kw. total capacity, and the largest machine was 500kw.; on the same system in 1907 considerably over 100,000kw. was in operation, the largest units being 2000kw.

Most of the larger systems using synchronous converters operate at 25 cycles, but during the last four or five years many systems using 60 cycles have adopted synchronous converters and have found them very reliable; it can be safely said that 60-cycle synchronous converters, even when used for 600-volt railway work where the demands of the service are most severe, can be considered thoroughly reliable and successful, machines as large as 1500kw. being in successful operation.

The general tendency in the design of synchronous converters has been toward higher speeds, which would naturally mean reduction in the space occupied by them, lower first cost, less weight, &c. All these changes result in smaller buildings, cheaper foundations, and consequently lower fixed charges.

As an illustration of the changes that have been made, the author cites one example. The 2000kw., 25-cycle, 250-volt synchronous converter as originally designed operated at 115 revolutions, and had 26 poles. It occupied a floor space 190in. by 204in., and the total weight was approximately 186,000lb., whereas the newer vertical machine is circular in form, the diameter being 182in., and the total weight about 130,000lb.

Vertical synchronous converters. The vertical synchronous converter is so new that it seems advisable to point out some of its essential characteristics. The most novel features are in the shaft and bearings. The shaft, unlike that of the horizontal machine, is stationary; in fact it is nothing but a pedestal supported and fastened solidly to the foundations. There is only one bearing, which carries the entire weight of the revolving structure. This bearing in the first machine built consisted simply of two cast-iron plates, one of which was fastened to the top of the pedestal, and the other being bolted to the spider of the armature. Fig. 1, a cross-sectional view of the machine, shows more clearly this construction. Oil is pumped up through a central hole in the pedestal and forced out between the cast-iron plates, forming an oil film on which the machine revolves and making practically a frictionless bearing.

In addition to the main bearing, use is made of the entire length of the interior of the spider for a guide bearing. A cast-iron

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*Abstract of paper read before the American Institute of Electrical Engineers, New York, Feb. 14, 1908.

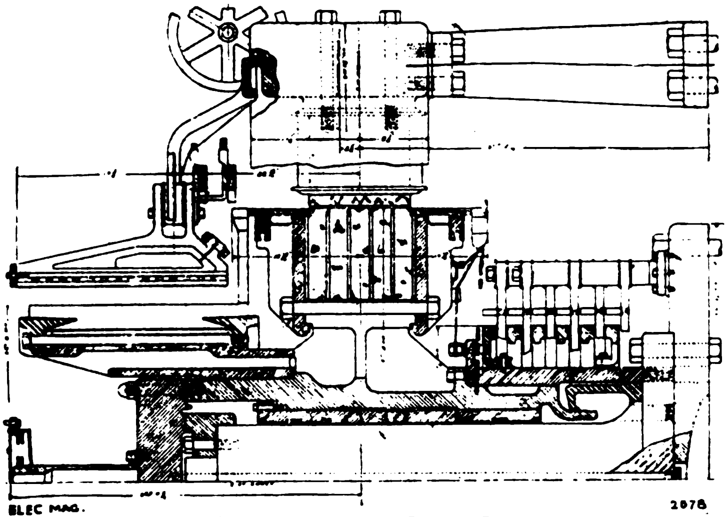

Fig. 1. Section of Vertical Rotary Converter.

sleeve lined with babbitt is fitted into the spider to form the bearing surface. As the only weight on this bearing is that due to the unbalancing of the rotating structure, the bearing should last indefinitely. The oil after leaving the top or supporting bearing passes along the pedestal (thus oiling the guide bearing) down to the pocket at the base of the machine, where it is drained off and used over again. Since the first machine was built, a new type of bearing has been tried which gives promise of success, although only a few months' experience has been obtained as yet.

Fig. 2 shows in general the parts which are used to make up this bearing. The cup-shaped cast-iron piece is fastened to the top of the pedestal and forms a seat for the hardened steel bearing plate and carrier, the steel plate being simply dowelled in place. Both sides of this plate are accurately ground so that it can be reversed in case of any damage to one surface. It can readily be seen that this construction of the two lower members of the bearing makes it self-aligning.

The top part of the bearing is bolted to the armature spider and is similar to the top of the oil-pressure bearing, except that another hardened steel plate is dowelled in place on the under part of this casting to form the wearing surface. Between these steel plates is a bronze carrier with a number of hardened steel rollers placed radially, thus forming the roller bearing. Oil is pumped by a small low-pressure pump to this roller bearing and is drained off after passing through the guide bearing in exactly the same manner as with the oil step.

The stationary part carries the field spools and is split vertically so that the two halves can be drawn apart, making the armature accessible for inspection or repairs. This frame is supported on a number of cast-iron pedestals.

By the above construction it will be noted that the field frame is entirely independent of the rotating structure, making it easier to assemble the machine.

The armature being revolved around the pedestal, it is not possible to obtain any end-play, as in a horizontal machine. Some means must be provided to make the wear on the collector rings equal; this is accomplished by designing the brushes in such a manner as to make it possible to stagger

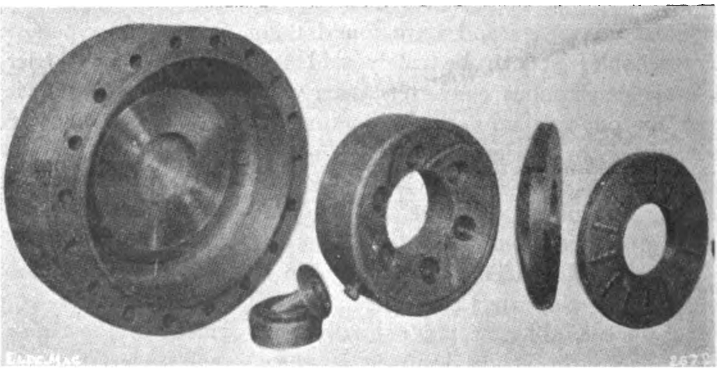

Fig. 2. Parts of Vertical Converter Bearing.

them and thus cover the entire width of the collector rings. In addition there are placed on each ring some graphite brushes which act as lubricants.

Fig. 3 is an elevation of the first 2000kw. machine of the vertical type which has been constructed. By reference to this illustration it will be seen how accessible the machine is. It is possible to walk around the machine and see and adjust all the brushes on both the commutator and the collector rings without climbing up on a bearing pedestal or going down into a pit, as would be necessary in a large horizontal shaft machine. The bearings in the 2000kw. vertical machine can be taken out, inspected, and replaced in a little over two hours, which would hardly be possible in a horizontal machine of the same size.

The construction above outlined makes it possible to build machines occupying minimum floor space; in fact it has been found possible in stations which have been laid out for 1000kw. machines, horizontal shaft of the old type, to place a similar number of vertical machines of double the capacity.

Voltage Regulation.—The next matter is that of voltage regulation. With a synchronous converter, as is well known, it is not possible to regulate the direct voltage of the machine by means of the field rheostat, as is done with a direct-current generator, without changing the power-factor; for the ratio between the impressed alternating voltage and the direct voltage is fixed by the design of the machine. Hence where voltage regulation is necessary, as for lighting work, charging storage batteries, &c., some means of changing the impressed alternating voltage is necessary.

A number of different methods have been used to accomplish this result:

1. On the step-down transformers used with the converter, taps can be placed either on the primary or the secondary side and switches used to transfer from one tap to another. This scheme has many objections, and is seldom used now. If the taps are on the primary, oil-switches would have to be used if the voltage were at all high; such switches would be practically out of the question. If the taps are on the secondary, a dial-switch can be used, but only with the smaller sizes of machines, as it is difficult to build a dial switch to handle large currents satisfactorily except at prohibitive expense. This method is also objectionable, as it means fluctuation in the lights whenever the switch is moved to a different tap.

2. The common way of obtaining control of the voltage in railway work is to insert in the leads from the secondary of the transformer a reactance, thus causing an artificial drop in the impressed alternating voltage. This method, while simple and effective with the limited ranges in voltage required for such work, would not be applicable for large ranges in voltage. Too much reactance may cause pulsation troubles and it also has a bad effect on the entire system.

3. The arrangement in most general use to-day is to connect between the secondary leads of the transformer and the synchronous converter an induction regulator, by which it is possible to obtain almost any range of voltage within the capacity of the machine.

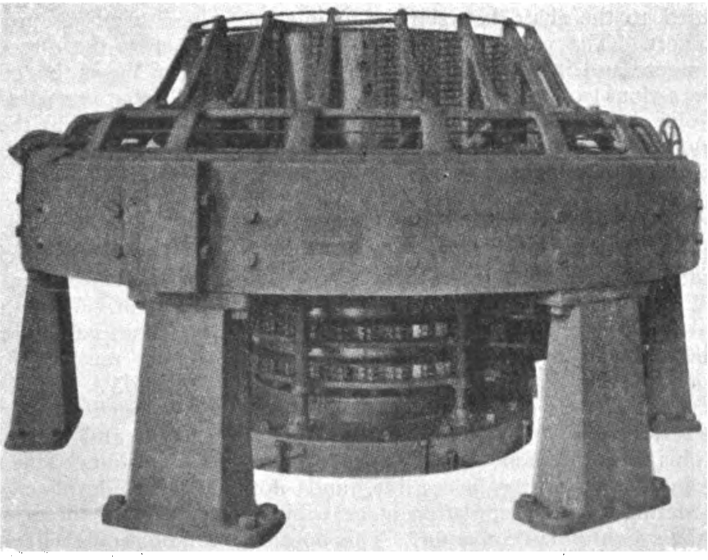

FIG. 3. A 2000KW. VERTICAL CONVERTER.

This scheme of operation is in such general use that it will not be necessary to describe it in detail. The principal objection to this arrangement is that another piece of operating machinery is used with each synchronous converter outfit, increasing the cost, requiring valuable floor space, and making it necessary to open the secondary leads from the transformer, a complication with large low-voltage machines.

4. This method makes use of an alternating-current booster mounted on the same base with the synchronous converter. The field has the same number of poles as the converter, and the armature is mounted on the same shaft as the synchronous converter armature. Alternating current is generated in this armature, and can be made to add its voltage to or be subtracted from the impressed voltage according to the direction of the excitation. This booster is usually placed between the collector rings and the main armature of the converter, and the taps from the collector rings are connected to equidistant points of the booster armature; similar points on the booster armature are connected to the synchronous converter armature, thus placing the two in series, separate and distinct windings for each phase being used.

The principal objections to such an arrangement are that here again is an additional operating machine, as in the case of an induction regulator. Extra weight is added to the shaft between its points of support. The ventilation of the converter armature and its accessibility are impaired. Any serious trouble with this smaller machine results in the dismantling of the main synchronous converter in order to repair the small booster.

Another way to construct such a machine is to make it a revolving field machine, mounting the field on an extension of the shaft beyond the bearing of the collector-ring end of the synchronous converter.

As the armature is stationary, the leads from the secondary of the transformer are led directly to this winding, and from this winding to the collector rings of the synchronous converter.

This arrangement has the twofold advantage of being accessible, and not interfering with the ventilation or accessibility of the synchronous converter. This booster can be applied to any standard converter, and being overhung, it is possible to carry a spare machine which can be placed in position quickly and without interfering with the body of the main synchronous converter.

5. The next development is very radical and is unlike any of the other schemes used. It was first proposed by J. L. Woodbridge some time ago.* It has been known for some time that the ratio of conversion between the alternating current and direct current sides of a synchronous converter could be changed by varying the width of the pole-face. The Woodbridge method makes use of this idea in a very simple and yet effective way.

Fig. 4 shows a two-pole synchronous converter equipped in accordance with this idea. Each field pole is divided into three sections, on each side of which are two windings. One of the windings on each section is the main shunt winding, and the other is the regulating winding.

All the main windings are connected in series and excited in the ordinary manner. The regulating windings, however, are connected differently. The windings on the two outer sections of all poles are connected in series with one another and the windings of all the central sections are connected in series with one another.

The voltage of the direct-current side of the converter is increased by exciting all the outer sections in a direction to assist the main shunt field, and the middle section an equal amount in opposition to the main field. This condition is shown in Fig. 5. If both these windings are excited in the opposite direction the direct voltage will be lowered. Fig. 6 shows this condition.

All that is needed in this arrangement is a field rheostat in the regulating field circuits in addition to the main field rheostat ordinarily used.

The first question that comes up with this scheme is, What effect has it on the power-factor? A number of machines arranged this way have been designed and placed in operation. With these machines the power-factor can be held constant at all loads, yet all the range in voltage desired can be obtained.

6. Since this method was proposed, another and still simpler method has been brought out. This scheme was proposed by Mr. J. L. Burnham. Instead of making each pole with three sections and with two windings on each, only two sections are used. On each section only one winding is used. The large section corresponds to the main

shunt winding on an ordinary synchronous converter, while the regulation is obtained entirely by changing the excitation of the smaller section, exciting it in one direction to boost the voltage, and in the other to lower the voltage.

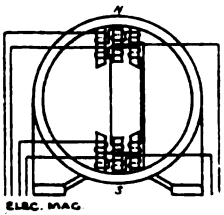

Fig. 4.

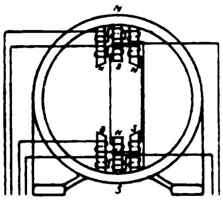

Fig. 5.

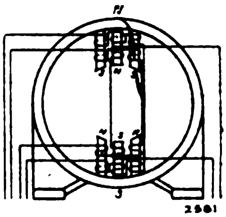

Fig. 6.

Anti-hunting devices of many types have been designed and put in operation, most of which have been reasonably successful. The latest, and in many ways the most efficient form of bridge, is formed by placing some copper rods directly through the face of the pole tips. These copper rods are all joined together by heavy copper rings, thus forming a complete squirrel-cage winding similar to that used on the rotor of an induction motor.

These rods being placed directly through the pole face are naturally in the main flux and consequently form very efficient dampers.

There are many conditions existing in different parts of the country which have made it advisable to use some special form of connection for the transformers, but the general practice is to use the diametrical connection with all six-phase machines. This connection is particularly useful in lighting work, as it provides a ready means for obtaining a neutral. With three-phase converters the transformers are usually connected in delta.

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Helion Lamp Patents.

A description of the Helion incandescent lamp, in which the inventors gave full particulars of its development and test results, appeared in The Electrical Magazine of February last year. Three American patents were recently issued to W. G. Clark on processes for making the incandescent lamp filaments which consist of a combination of silicon and carbon. The deposits of silicon have been obtained by the decomposition of chlorides, and the object of the patent is to obviate the difficulty that has been experienced in getting a uniform product and to prevent the chlorine once free from combining with the silicon. The first of the several patents describes a process wherein a carbon filament is placed into a receiver containing a small quantity of mercury, after which a silicon chloride, such as a tetrachloride and also a gas which contains carbon, are introduced. When the current is passed through the filament the chloride is decomposed and the silicon deposited upon the carbon, and the free chloride combines with the mercury. The second patent covers the use of the carbon gas referred to above, the claims being for the mixture of marsh gas and an olefiant gas, or marsh gas, olefiant gas and carbon dioxide. The third patent states that the hydrocarbon gas may be some form of illuminating gas, but is preferably the marsh gas. When the deposition on the filament takes place the silicon and combination of silicon and carbon, which is a dense, non-porous combination, enter the pores of the carbon base, combine with and build up on the base, so that the latter becomes a combination of silicon and carbon, which gradually merges near the surface into a substance having characteristics similar to those of silicon.

◆

Variation of Candle Power of Metallic Filament Lamps with Voltage.

The results of tests made on Nernst, carbon, tantalum, osmium, and tungsten lamps are given in an article by F. Hirschauer in a recent number of the *Elektrotechnische Zeitschrift.* It is shown that the candle power varies as the tenth power of the voltage in the case of the Nernst lamp, as the 6.3 power with the carbon-lamp, the 4.3 power with the tantalum lamp, and the fourth power with the osram and tungsten lamps. It would seem therefore that the new metallic filament lamps are not only of much higher efficiency than the older types, but that they have a further decided advantage in being less susceptible to the changes in terminal voltage which always occur more or less on public supply networks.

*PROTECTIVE DEVICES FOR HIGH-TENSION TRANSMISSION CIRCUITS.**

J. S. PECK.

COMPARATIVELY little has been done in Great Britain toward the study and development of apparatus for protecting high-tension transmission systems against lightning or other high-voltage discharges. At least three reasons may be assigned for this apparent lack of interest :—

1. There are very few systems working at pressures above 11,000 volts.
2. The great majority of transmission systems are laid under ground, and therefore not subjected to lightning disturbances.
3. Severe thunder-storms are of very rare occurrence.

The question of protective apparatus for high-voltage transmission systems is, however, one which even in Great Britain deserves careful consideration, for it is probable that voltages much higher than 11,000 will be used in future, and that overhead transmission will come into more extensive use both for present voltages and for higher ones, and although climatic conditions are not likely to become more severe, static disturbances are not produced by lightning alone, but by switching, grounding, short-circuiting, &c. Underground cable systems are particularly subject to such disturbances on account of their great static capacity as compared with overhead systems.*

Static Disturbances.—Static disturbances may be produced in a number of different ways, namely, by switching, short-circuiting, grounding, and lightning, or in any other way which produces a very abrupt change in potential. The distinguishing features of static disturbances are their oscillatory nature and their extreme suddenness of action. In the case of lightning discharges, the frequency may be thousands or even millions of cycles per second. In the case of switching, grounding, &c., the changes in potential are practically instantaneous on those parts of the circuit nearest to the point where the grounding or switching occurs.

Concentration of Potential.—One of the best-known static effects is the concentration of potential upon the outer turns of the windings of electrical apparatus. Fig. 1 shows diagrammatically the high-tension and low-tension windings of a transformer. Each turn of the high-tension winding has a static capacity to the low-tension winding and to ground. Each turn also has a certain amount of inductance. S represents a switch, by means of which one outer turn of the high-tension winding is connected to the line circuit. Before switch S is closed both windings are at zero potential. When switch S is nearly closed a spark passes from the line to turn No. 1 at the instant of maximum line voltage. This turn is immediately brought up to line potential, and turns 2, 3, 4, &c., follow it rapidly, but no turn can reach full potential until the

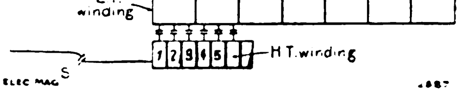

FIG. 1.

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* The term "static" as applied to phenomena which are distinguished chiefly by the extreme suddenness with which they act seems certainly a misnomer, and it has been proposed to call them "lightning phenomena," distinguishing between cloud lightning and lightning due to switching, &c., by the terms "external" and "internal"; but as this point has not yet been settled, and as static is the term in most common use, it will be used in this paper.

* Abstract of paper read before the Institution of Electrical Engineers, Manchester Local Section.

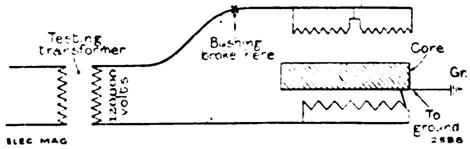

FIG. 2.

condenser connected to it is fully charged. For example, turn 3 cannot reach its full potential above earth until the condensers connecting it with earth have been fully charged, but the current to charge these condensers must pass through turns 1 and 2, and since these turns possess an appreciable self-induction, an appreciable time is necessary for the current required to charge these condensers to flow through turns 1 and 2. Thus for an extremely short period of time the full potential of the line will be concentrated upon a very few of the outer turns of the transformer. In a 10,000-volt transformer there may be normally a difference of potential of, say, 40 volts between turns. One of the line terminals is 5000 volts above earth potential, and the other 5000 volts below. At the instant of closing the positive line switch the full potential of the line above earth, *i.e.*, 5000 volts, may be concentrated upon a half-dozen turns, thus giving, perhaps, 500 volts or more between individual turns, and unless very heavily insulated a spark may pass between them. In a small fraction of a second the whole of the high-tension winding will have assumed the potential of the line. If, now, the other terminal of the winding be connected to the negative side of the circuit a similar action takes place, except that whereas in the first case the high-tension winding was at earth potential it is now 5000 volts above earth, so that when the positive end is connected to earth the strains are approximately double what they were when the first switch was closed, and there may be over 1000 volts per turn where there should be but 40 normally.

This effect is produced not only by switching, but by any action which causes a very abrupt change in potential of the end turns of a transformer. For example, if one terminal is 5000 volts above earth and is suddenly earthed, the first turn is reduced instantly to zero potential, and there is the same concentration of potential as in the case of switching the transformer on to the line. A static charge produced by lightning, surging along the line and meeting the transformer windings, produces a similar effect.

This effect of concentrated potential was clearly shown in the case of a large high-voltage transformer which was under test. The transformer was connected as shown in Fig. 2, and 120,000 volts applied between three points of the high-tension winding and the low-tension winding which was connected to the core. While the voltage was being applied a bushing on the testing transformer punctured and grounded the terminal connected to the high-tension winding. The bushing was replaced, the test repeated, and the insulation proved to be satisfactory. As the transformer had been tested previously under full load, it was prepared for shipment, but as it was desired to check the iron loss, voltage was put across the terminals, when it was found that the transformer was short-circuited. When dismantled it was found that a static discharge had passed over several turns adjacent to the three points where the testing transformer was connected to the high-tension winding. This discharge had punctured the insulation between adjacent turns and short-circuited them, but caused no other damage whatever.

This concentration of potential may occur in a high-voltage motor or generator in exactly the same way as explained above in the case of a transformer; in fact, high-voltage motors and generators are particularly subject to damage from this cause on account of the great difficulty of insulating the individual turns from each other. Transformers are much easier to insulate, and, in general, it is not necessary to take any special precautions in switching transformers wound for voltages not exceeding 11,000, but for very high voltages special precautions must be taken. The voltage between turns depends upon the suddenness of the discharge and the capacity and inductance of the windings. It should be noted that this concentration of potential has no tendency to cause a breakdown to earth, but to produce short-circuits between adjacent turns. It is one of the most frequent sources of trouble in high voltage apparatus.

This concentration of potential may be illustrated in a rough way by means of a

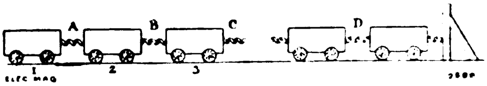

FIG. 3.

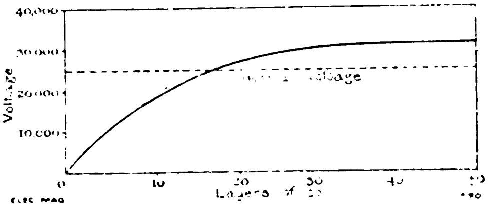

FIG. 4.

mechanical analogy. Fig. 3 represents a line of wagons separated by springs. If wagon No. 1 is moved slowly toward the right for a certain distance, spring A is slowly compressed; wagon No. 2 begins to move toward the right, spring B is compressed; wagon No. 3 begins to move, &c. The whole movement is a gradual one, and no excess pressures are brought on any of the springs between the wagons. The wagons will come to rest with a slight and equally divided compression upon all the springs. If, however, wagon No. 1 is moved with great suddenness to the right, spring A will be suddenly compressed, wagon No. 2 will begin to move, but on account of its inertia, it cannot get under way immediately. As it does begin to move, spring B is compressed, but wagon No. 3, because of its inertia, cannot be set in motion instantly. Therefore, for a short period of time, the full compression represented by the movement of wagon No. 1 will be concentrated on the springs between two or three of the wagons. The extent to which the springs between the first few wagons will be compressed depends upon the suddenness with which wagon No. 1 is moved, upon the flexibility of the springs, and upon the inertia of the wagons. It is evident that the spring compression moves on from one wagon to the other until it reaches the end where it is reflected, and the wagons oscillate back and forth until they all come to rest. In this analogy the springs correspond to capacity and the inertia of the wagons to inductance, though the distribution is not the same as in the transformer winding.

Fig. 4 shows a curve illustrating this concentration of potential on the end turns of a transformer.

Reflected Waves.—If a condenser is fully charged and then discharged through a reactance, the current will increase until the condenser is entirely discharged, when the whole of the energy will be stored in the reactance; but the energy cannot remain thus stored, and the reactance begins to discharge into the condenser, which is charged to its original potential, but in the opposite direction. The condenser cannot remain charged, but again discharges into the reactance, so that the charge oscillates between reactance and condenser until it is used up in ohmic loss and leakage.

Referring again to the wagon analogy, if the wagon in Fig. 5 is moved slowly toward the right until the spring A is under 100lb. pressure and then released, the wagon will begin to move toward the left with increasing velocity. The velocity will reach a maximum when the spring is in its normal position, but the inertia of the wagon will carry it to the left until the spring is under 100lb. tension. The spring will then begin to move the wagon to the right, and the cycle will be repeated until the energy originally imparted to the wagon has been absorbed in friction.

If a condenser is without charge, and we charge it from a constant potential line through a reactance, current flows into the condenser through the reactance at an increasing rate, which reaches a maximum when the condenser reaches line pressure. The current through the reactance cannot stop, however, but continues to flow into the condenser until it is charged to double-line pressure. The condenser, however, cannot remain at double potential, but discharges through the reactance into the line, and continues to oscillate between zero and double-line pressure until it finally comes to rest at line pressure. Thus it is possible to obtain double the original pressure on a condenser when charging it through reactance. If in Fig. 5 we push against the wagon with a steady pressure of 100lb., it will move toward the right with increasing velocity, which reaches a maximum when the spring is under 100lb. pressure, but the inertia of the wagon carries it forward until the spring is under

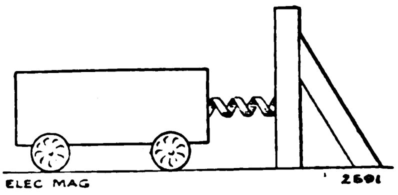

FIG. 5.

200lb. pressure. The spring then forces the wagon to the left until the spring is under zero compression. The wagon then starts again toward the right, and the cycle is repeated until it finally comes to rest with the spring under 100lb. pressure.

A transmission line is made up of condensers and reactances in series. If an unloaded line is connected at one end to a constant potential source, a charge passes into the line and advances at a certain rate depending upon the constants of the line. When it reaches the open end of the line it can go no further, but on account of the inductance of the circuit the charge is increased until approximately double potential is reached at the end of the line (somewhat as double pressure was put upon the spring in Fig. 5), but the end of the line cannot remain at double potential, and the charge is reflected back along the line, bringing it to double potential. The next wave reduces it to line potential, and the reflected wave to zero potential. Thus the line oscillates from zero to double-line potential until it finally comes to rest at line potential.

The phenomena just described may perhaps be understood better from a water analogy. If we have a long, narrow trough containing water, and displace the water at one end so as to start a wave along the trough, the wave progresses until it strikes the end of the trough. Here it reaches double its original height and is reflected back along the trough.

It is not necessary that the line should be open-circuited in order to obtain a reflected wave and a potential rise, for if there is a branch line at the end of the main line and the branch has less capacity than the main line, it will be unable to absorb the charge as rapidly as it arrives at the junction, and a rise in potential will occur. Thus if there is a circuit made up of underground cables and overhead wires, and a potential is impressed on the far end of the underground circuit, a charge will travel along this circuit until it reaches the overhead conductors. As their capacity is much less than that of the underground circuit, a high voltage will occur at the junction. The maximum possible pressure at this point is double the line pressure, but it is probable that this maximum value is very seldom reached. The high potential at the junction passes along the overhead circuit, and is reflected at the open end, where it may again be doubled, thus giving as a maximum four times the original line pressure.

Resonance.—If the wagon and the spring in Fig. 5 are set in motion they will oscillate back and forth at a certain definite rate which will be determined by the inertia of the wagon and the flexibility of the spring. If we start them oscillating, and every time the wagon moves to the right give it a push in that direction, and every time it moves toward the left give it a push in that direction, the travel of the wagon and the compression and extension of the spring will gradually increase until the spring breaks, or until the resistance to further movement is greater than the push given it each oscillation. The push may not come every oscillation, as the same effect is obtained if it occurs every second or third, or as long as the push is in the same direction as that in which the wagon is moving. A similar condition may occur on a transmission line which is made up of condensers and reactances in series. Every line has a natural period of oscillation, and if the frequency of the generator is such as to increase the magnitude of the oscillation, resonance occurs, and there is practically no limit to the voltage which may result. Fortunately the frequency of oscillation of a transmission line is so high that there is very little chance of resonance with the generator frequency.

On very long lines there is, however, the possibility that there may be resonance with some of the higher harmonics, and for this reason it is desirable that the generator should deliver an e.m.f. wave which has as nearly as possible a sine-form.*

The static disturbances described above may be said to be caused by internal workings, but the most severe strains to which apparatus is subjected are due to an external cause—lightning.

Lightning.—There are three ways in

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* The natural frequency F of a circuit—

$$= \frac{1}{2\pi\sqrt{LC}}$$

where L is expressed in henrys and C in farads. For an ordinary transmission line 20 miles long, L may be taken as 0.075 and C as 0.16×10^{-6}.

Therefore—

$$F = \frac{1}{2\pi\sqrt{\frac{0.075 \times 0.16}{10^6}}} = 1600 \sim \text{ per second.}$$

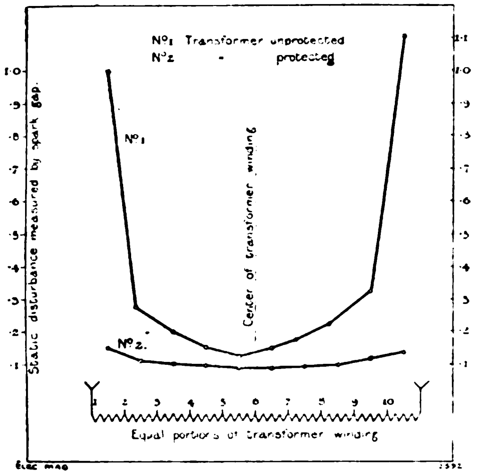

FIG. 6.

which lightning may affect a transmission line:—

1. By static induction.
2. By magnetic induction.
3. By direct stroke.

If a charged cloud approaches a transmission line, a charge of opposite sign is induced by static induction on the wires, the charge of like sign being repelled and leaking gradually from the wires to earth. If the cloud is suddenly discharged by a stroke to earth the line wires are left charged to a high potential, and this charge tries to escape to earth. If the line is well insulated, so that the charge cannot reach ground over the insulators, it rushes along until it reaches the apparatus connected to the line, and if there is a weak spot it jumps to earth at this point. If the insulation is strong everywhere in the system, or the potential of the charge not sufficiently high to jump to earth, it oscillates back and forth on the wires until dissipated in ohmic losses and leakage.

If a lightning discharge occurs parallel to a transmission line, the field set up by the discharge induces a charge in the wires by magnetic induction. As the lightning stroke is of an oscillatory nature, the charge on the wires is of the same nature, and either jumps to ground or oscillates back and forth until its energy is dissipated.

When a direct lightning discharge strikes a transmission wire it usually jumps to ground over the nearest insulators, often destroying the pole. Many cases have been known where a number of poles have been shattered by a single stroke. In the case of direct stroke the apparatus in the station may be uninjured, as the discharge to ground over the insulators is the means of saving the station apparatus.

It should be borne in mind that these lightning discharges are characterised by their extreme suddenness and by their oscillatory nature. Their frequency is enormous as compared with that of the highest frequency alternating systems in operation. At these extremely high frequencies circuits which offer practically no inductance to currents of normal frequencies become highly inductive, and capacity effects are correspondingly increased.

It has been found also that in dry climates wind blowing over the transmission wires, or other climatic conditions, will gradually build up a high static potential which may cause damage to the apparatus. The best way to relieve the line from charges of this nature is to connect a high resistance between wires and ground through which the static charge may escape to earth.

It is evident from what has been said that, regardless of the source of the static disturbance, there are at least two dangers to electrical apparatus on transmission systems:—

1. Concentration of potential on the end

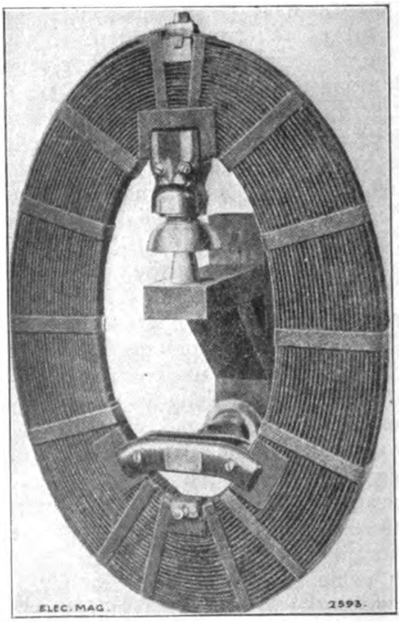

FIG. 7.

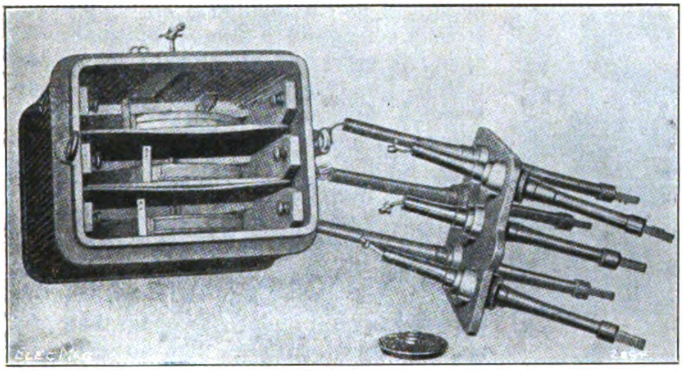

FIG. 8.

windings, causing shorts between adjacent turns.

2. Excessive voltage between wires and ground, causing breakdowns to ground over insulators, bushings, or through the insulation of the windings.

In order to prevent trouble from the first cause, two courses are open—

(*a*) To insulate the end windings so that they will withstand the strains. This method is often used, but it is always expensive, and on certain types of apparatus very difficult to apply.

(*b*) To prevent the windings being subjected to the abrupt change of potential. In the case of switching, danger may be prevented by closing the circuit through a resistance or adopting certain other means, but the most effective remedy, and one which is good for practically all cases, is to place choke coils between the apparatus and the lines from which the static disturbance comes. With this arrangement the shock is taken by the choke coils, which can be heavily insulated to withstand it, and if the coils should break down they are readily repaired or replaced. The use of a choke coil may be said to be the same (so far as the static strains are concerned) as placing the end turns outside the apparatus, where there is plenty of room for insulation. The effect of a choke coil in reducing strains on the end windings of a transformer is shown in Fig. 6, where the voltages across different numbers of turns near the line are measured with and without a choke coil.

The greater the reactance or choking power of the coil, the greater is its retarding effect upon the discharge, and therefore the greater its protective power. On the other hand, the greater is its cost, and the greater drop it introduces into the circuit. In general, however, a very fair degree of protection may be obtained from a coil of comparatively low cost and with negligible drop. Two types of choke coils are shown in Figs. 7 and 8.

In order to prevent trouble from the second cause, that is, high voltage to earth, the lightning arrester is used.

Lightning Arresters.—The lightning arrester is intended to afford a path to earth for static discharges of lower resistance than that offered by the insulation of the transmission line or of the apparatus connected to it. The requirements for a good arrester are conflicting. It must offer an easy path to earth, yet must be able to hold back the line voltage, and when a discharge occurs it must be able to interrupt or suppress the arc which follows the discharge. All arresters, except the water jet type, consist of at least one air-gap in series with an arc-suppressing device. In the case of alternate-current arresters there are often a very large number of gaps in series.

Horn-type Arrester.—A great many different types of arresters have been developed from time to time. The earliest form was

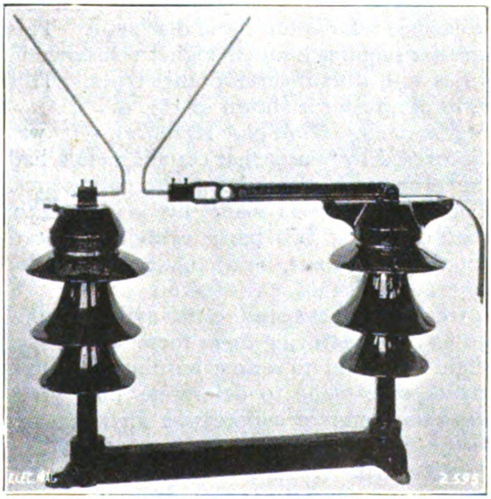

FIG. 9.

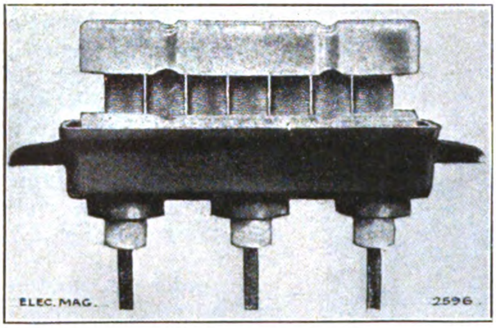

FIG. 10.

probably the horn type, which consists of two wires, or rods, each bent at an acute angle, the two being placed in such a position that the air-gap is small at the bottom, but increases rapidly from bottom to top. One horn of the arrester is connected to line and the other to ground, and the arrester so adjusted that the gap at the bottom is just large enough to withstand normal or slight increases above normal voltage. When there is an excess voltage an arc passes across the small part of the gap, and due to its heat rises until it is drawn out so long that it is ruptured. The advantage of this type of arrester is that it is cheap and can be installed out of doors.

The objections are that the arc takes a long time to break, and, since it constitutes a short-circuit on the system, will throw synchronous apparatus out of step. It is now customary to install a high resistance in series with this arrester in order to limit the current which flows on short-circuit, but this resistance retards the static discharge. This arrester requires a much higher resistance in series with it than certain other types. This form of arrester is shown in Fig. 9.

Non-arcing Multi-gap Arresters.—It was discovered by Wurts that certain metals had the property of suppressing alternating arcs. The discovery was made by inadvertently short-circuiting two brass cylinders spaced about $\frac{1}{32}$in. apart, and connected to the opposite sides of a 1000-volt circuit. A spark passed between the two cylinders, but instead of destroying them there was only a slight spark and no serious burning. Experiments were made to determine how great was this power of suppressing an arc, what its limitations were, and what metals possessed it. A large number of experiments were carried on with different metals, and the best one was adopted for the manufacture of non-arcing metal arresters. This arrester consists of a number of small metal cylinders separated by air-gaps of approximately $\frac{1}{32}$in. (Fig. 10). The number of gaps between line and ground is made great enough to suppress any arcing which occurs after a static discharge. This arrester proved a great success on circuits of 2000 volts, and was used to some extent on voltages as high as 15,000 and 20,000. It was found, however, that on large generating systems, and particularly with high voltages, the arresters did not always retain their non-arcing quality, or else that an enormous number of gaps were required.

At this time Thomas began his investigations with a view to producing an arrester which would be satisfactory on circuits of any voltage and of any capacity. He discovered that in order that an arrester should be non-arcing it was necessary to limit the amount of current which flowed after the arrester discharged. This at once suggested an ohmic resistance in series with the gaps, but on high potential circuits the insertion of sufficient resistance to render the arrester non-arcing increased greatly the resistance which the arrester offered to static discharges. He found, however, that the resistance of the arrester to static discharges could be greatly reduced by using a large number of gaps and comparatively small series resistance, and shunting part of the gaps with an ohmic resistance. This he called a low equivalent arrester, the general connections of which are shown in Fig. 11. The action of the arrester is as follows :—

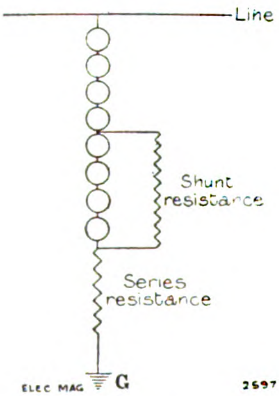

FIG. 11.

Approximately twice as many gap units are taken as are required to hold back the

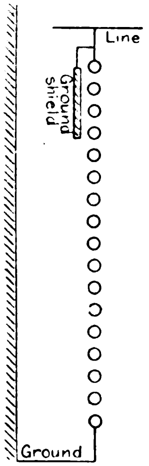

FIG. 12.

line voltage. Approximately one-half of the gaps are shunted with an ohmic resistance. When no discharge occurs the ground potential is brought up to the middle of the series. Thus there are between line and ground only one-half the total number of gaps. When there is an excessive potential on the line, the non-shunted gaps break down first, so that full potential is thrown across the shunted gaps, and they also break down. The arc through the shunted gaps is, however, very unstable and quickly drops out, the current passing through the shunt resistance, but the non-shunted gaps now have in series with them the shunt resistance and the series resistance, so that the current passing through them is very small and the arc is quickly suppressed. Although the two series of gaps do not break down simultaneously, the whole action is, of course, very sudden and appears instantaneous. This arrester has been very successful, and the principle with various modifications is now used on practically all arresters of the multi-gap type.*

One objection to the multi-gap arrester is that on high voltages an increase in the number of gaps out of all proportion to the increase in voltage is required in order to hold back the line voltage and to make the arrester non-arcing. It was found also that the number of gaps varied greatly on different circuits, and this difference was finally traced to the position of the arrester with reference to grounded objects. The explanation of the phenomena is believed to be as follows:—

When ground potential is brought near the arrester, the potential gradient across the gaps near the line becomes so high that the air between the cylinders becomes ionised, and the line potential is gradually moved towards the grounded end of the arrester until there are not sufficient gaps to hold back the line voltage and a discharge occurs. When the arrester is well removed from grounded objects, *i.e.*, from the walls of buildings, &c., the total potential strain from line to ground is divided more equally between the cylinders, consequently the arrester will stand a higher potential, or a smaller number of gaps are required for holding back the same potential.

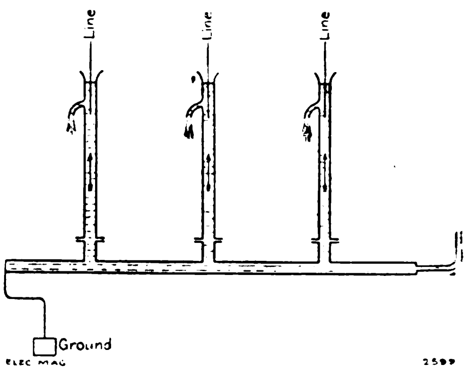

FIG. 13.

With high-potential arresters a hissing sound is often noticeable. This is caused by static sparks which pass continuously from the line wire to the cylinders which are adjacent to them. The closer the arrester is to grounded objects, the further will this display extend downward toward the ground from the line terminal. To overcome this unequal distribution of potential across the gaps, a metallic ground shield connected to the line is placed adjacent to a portion of the gaps furthest from the ground, thus the line potential is brought near to these gaps, and the excessive potential gradient removed. This arrangement is shown diagrammatically in Fig. 12. It is found in practice that the use of the shield often permits a great reduction in the number of gaps to be made.

Multiplex Arrester.— While the lightning arrester is intended primarily to afford an easy path to earth for static discharges, it has been found that a high static potential sometimes exists between the different wires of a

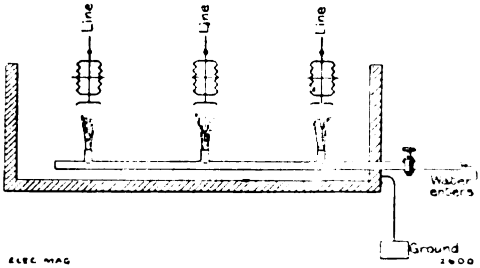

FIG. 14.

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* Recently a number of low equivalent arresters have been installed in which the series resistance is shunted by a fuse in series with a spark-gap. Under very severe discharges the fuse blows, showing that the voltage across the resistance is high enough to jump the gap, while the melting of the fuse shows that a heavy current has passed and afforded relief to the system.

transmission circuit. To take care of this, the General Electric Company of America brought out the multiplex arrester. In this arrester, which is of the multi-gap type, an ohmic resistance is connected from about the middle point of the series of gaps in one phase to the corresponding point of the arrester in the next phase. Thus all the arresters are connected together by a high ohmic resistance at approximately their middle points, and it is possible for a static discharge to pass half-way through one arrester, through the ohmic resistance, and through half the number of gaps in the other arrester to the opposite side of the circuit. Service tests indicate that this arrangement is sometimes of advantage, though practically the same result is obtained by the arrangement of the low equivalent arrester.

Water-jet Arresters.— On the Continent an arrester consisting of jets of water playing upon the wires has been used to some extent. The chief objection to this type is that it causes a leakage of current to earth which represents a loss of power, and if the resistance is sufficiently high to prevent serious loss due to leakage, it may offer considerable resistance to static discharges. It is, however, comparatively cheap, and appears to have given satisfactory protection, and there is no reason why an air-gap should not be placed between the line and the jet, though this would increase the resistance to the discharge. Its use is limited to places where there is a supply of water, unless pumping is resorted to. There are a number of different forms of this arrester; two are shown in Figs. 13 and 14.

Arresters in Parallel.— Much discussion has taken place regarding the effect of series resistances in lightning arresters in retarding static discharges. The static charge is represented by a certain current at a certain voltage. If the resistance of the arrester is low enough, so that the voltage of the charge can force the current through the arrester resistance as fast as it arrives at the arrester, then there will be no further rise in potential, but if the resistance cannot pass the current at this rate, there will be reflection and a rise in potential. To overcome this difficulty a number of arresters may be installed in parallel, the arresters having different gaps and different resistances. The arrester with a minimum gap has the maximum resistance, and the arrester with a maximum gap has the minimum resistance. The theory of the operation is as follows:—

When a discharge occurs it will jump the smallest gap, and if the current is not too large for the resistance there will be no rise in potential, but if the current is too large there will be a rise in potential and the next larger gap will break down. With a very high rise the largest gap with minimum series resistance will break down.

On some transmission systems arresters have been installed which consist simply of a horn-gap in series with a fuse. The gap is set so high that it will be broken down only with a very high rise in potential. This arrester, which offers a direct path to earth, is probably as good a means as any yet devised for taking care of a direct lightning stroke. Several of these arresters are connected in parallel, and usually only one discharges at a time, so that the line is not left unprotected, and arrangements are made for replacing fuses quickly.

The Electrolytic Arrester.—It has been found that aluminium in certain electrolytes forms a non-conductive film on its surface. This film, although extremely thin, will withstand about 400 volts. At higher voltage the film is punctured with countless small holes and a large current is permitted to pass, but when the voltage drops below the critical value the film is reformed and prevents further passage of current. A sufficient number of these cells may be placed in series to withstand almost any voltage desired.

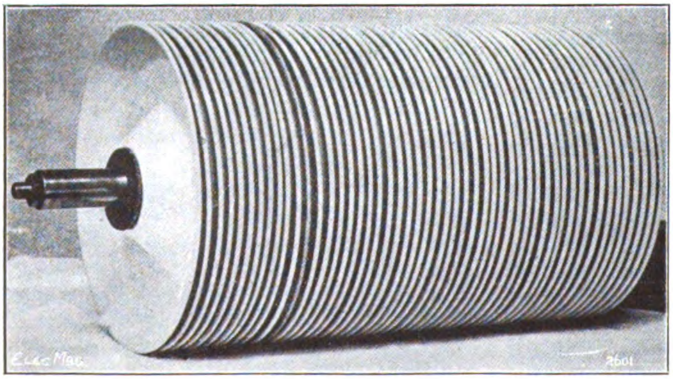


Fig. 15.

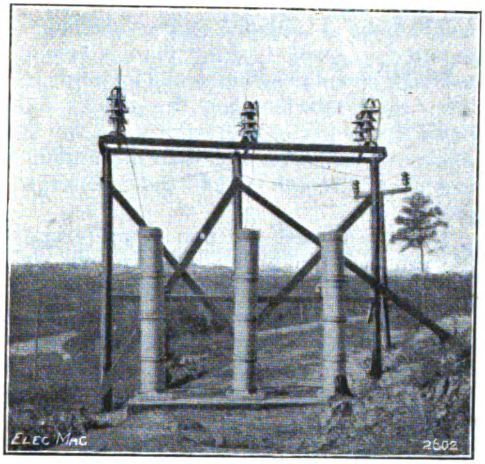


Fig. 16.

It is evident that the aluminium cell possesses almost ideal characteristics for a lightning arrester as it permits very little current to pass at normal voltage, but breaks down at higher voltage and re-seals itself as soon as the high voltage has passed and the line has been relieved.

When voltage is applied to the aluminium cell, a small current, partly capacity and partly leakage current, flows through it, and for a lightning arrester it is desirable to use a gap in series with the cell in order to prevent this current flow.

In order to obtain a large number of cells in series, the aluminium plates are pressed into tray form. These trays are set one inside the other (Fig. 15) and separated by suitable insulating washers. They may thus be built up into a column comprising a large number of cells in series. The columns are enclosed in suitable earthenware jars, and the trays filled with the electrolyte. This is done by filling the top tray and letting the electrolyte run over into those below. After the trays have been filled, the jar is tipped slightly, so that a small amount of the electrolyte runs out of each tray, and a small amount of transformer oil is then poured into the top tray and permitted to run over into those below. This oil prevents evaporation of the electrolyte. A number of jars may be mounted one above the other for high voltages, and as the edges of the trays do not touch the jars, current must pass from tray to tray.

For voltages not exceeding 13,500, a gap consisting of the usual non-arcing metal cylinders is placed between the line and the electrolytic unit. For higher voltages the horn-type gap is used. The gap used must have sufficient power to suppress the arc which exists after the static disturbance has passed. The current in this arc is quite small. It is not advisable to use a horn-type gap on the lower voltages, as it must be set so close that the arc does not rise properly and extinguish itself.

The electrolytic arrester is manufactured for voltages from 4000 to the highest in commercial use, and unless unforeseen difficulties arise it should practically solve the question of protection from lightning discharges.

Illustrations of this arrester are shown in Figs. 16 and 17, and oscillograph curves showing current and voltages on an electrolytic unit are shown in Fig. 18.

It is evident that no matter what type of lightning arrester is used, it must be set to discharge at a voltage considerably above the normal voltage of the line, so that before the arrester discharges the apparatus is subjected to a potential more or less above normal, depending upon the setting of the arrester.

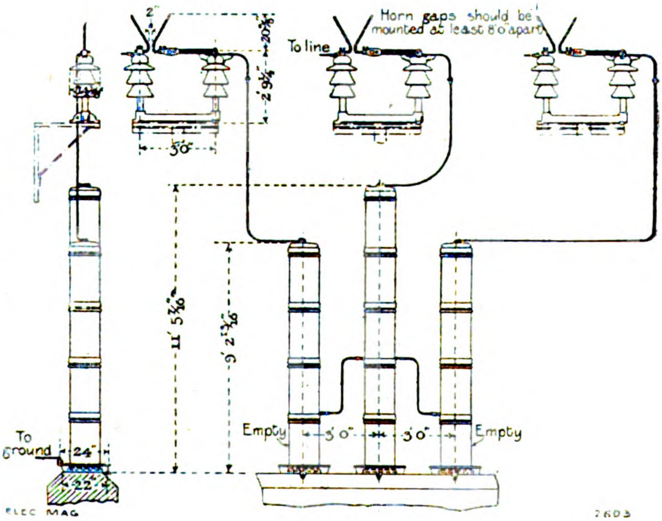


Fig. 17.

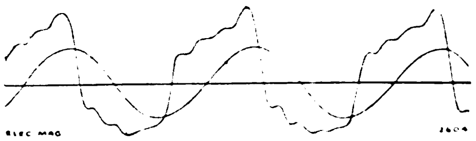


FIG. 18

Thus the insulation of the apparatus should have a good factor of safety if satisfactory operation is to be secured. Fortunately solid dielectrics have the power of withstanding momentary strains when they would break down under much lower strains applied continuously. This fact probably explains why insulation troubles from static disturbances are not very much more frequent than they really are.

Ground Wire.—The consensus of opinion seems to be that one of the best methods of protecting a transmission line from lightning is to string a wire above the transmission line, this wire being grounded at frequent intervals. Three wires, one above and one at each side of the transmission circuit, are recommended as affording very complete protection. It is the general practice, however, to install lightning arresters at the end of the line, whether ground wires are used or not.

Testing Lightning Arresters.—Before concluding this paper, a few words should be said regarding the methods of testing the protective power of lightning arresters. Fig. 19 shows one system of connections which is used. A condenser is charged to a high potential from a raising transformer. This condenser is discharged by means of a swing switch through a spark-gap in series with the arrester. In shunt to the arrester is an adjustable spark-gap, which affords an alternative path for the discharge. The gap is adjusted until the great majority of the discharges, say 95 per cent., pass through the arrester instead of over the gap. The length of the gap under this condition is called the equivalent spark-gap of the arrester, and means an air-gap of such a length that a slightly higher pressure is required to break it down than is required to break down the arrester. Obviously, the lower the equivalent gap, the greater is the protective power of the arrester, as the gap represents somewhat less than the minimum insulation strength which the arrester will protect.

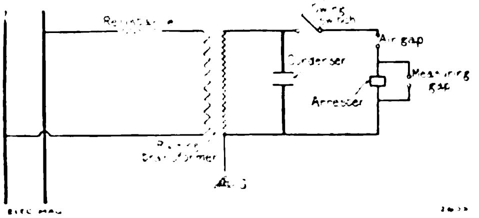


FIG. 19

In order to test the non-arcing power of the arrester, the adjustable spark-gap may be replaced by connections to the power circuit. When a discharge passes through the arrester, the arc which follows from the power circuit should be quickly suppressed.

Summary.—Static strains may be produced by lightning, switching, grounding, or by any occurrence which causes an abrupt change in static potential.

Static strains may appear as high pressure to earth or between wires, or as a concentration of potential upon a portion of the circuit.

To relieve the high-pressure between line and ground, or between wires, lightning arresters are used. To protect apparatus from concentration of potential, choke coils are placed in series with the apparatus to be protected, or the turns nearest to the line are heavily insulated, or both choke coils and additional insulation may be employed.

Electric Smelting of Tantalum.

A PATENT has recently been taken out for a process whereby homogeneous coherent bodies of tantalum are produced by smelting in an electric arc furnace. The tantalum to be smelted is placed on the positive electrode and the furnace is exhausted. A long and powerful arc may be started in the vacuum without bringing the electrodes in contact, if the residue of gas remaining in the vacuum furnace is first ionized. The ionization is effected by a metallic oxide being placed in the furnace and heated. The oxide is connected with the cathode and is heated by means of a platinum wire embedded in it. The wire is brought to incandescence by the passing of an electric current. Barium oxide is particularly suitable for this process. With a distance between the electrodes of several centimetres and a pressure of about 100 volts, an arc may be produced with a current of 50amp., sufficient to melt the tantalum.

VOLTMETER COMPENSATION FOR DROP IN ALTERNATING-CURRENT FEEDERS.

WILLIAM NESBIT.

THE drop in alternating-current feeders running out in various directions from a generating or sub-station varies in the different circuits, depending upon their length, the size of wire, the current being carried, and the power-factor. For this reason it is necessary to impress different voltages on the various feeders at their station ends in order to supply the proper voltage at the load. This is usually accomplished by the use of regulators in the feeder circuits at the station end, where the voltages may be independently regulated.

There are three methods in general use by which the voltage at the various feeding points is known under all conditions of load and power-factor. These are as follows :—

1. Two pressure wires are carried from the station voltmeter to the point at which the voltage is to be kept constant. The station voltmeter is calibrated with these pressure wires in circuit so as to indicate the voltage at the point where these wires are connected to the feeder circuit. With this method the station voltmeter will indicate the voltage at the load under all conditions of load and power-factor, provided there is no inductive effect upon the pressure wire caused by neighbouring circuits. This method is costly, complicated, and in most cases impractical.

2. Many station operators make a curve or a table for each feeder circuit, which curve or table indicates the voltage to be impressed on the circuit at the station end corresponding to various loads in amperes, in order that the desired voltage at the load may be maintained constant. This method gives correct results so long as the power-factor of the circuit remains the same as when the readings for the curve or table were taken. The principal objection to it is that it is necessary to consult the curve or table each time before adjusting the voltage, and then to find the new position on the voltmeter scale. This requires considerable time and tends to cause confusion. With this method the various feeder voltmeters will in general indicate different readings, and these readings will change each time adjustments are made.

3. The third method consists of inserting into the circuit of the feeder voltmeter at the station a sufficient amount of resistance and reactance to modify the station voltmeter reading in such a way that it will indicate accurately the voltage at the load under all conditions of load and power-factor. With this method (provided the load voltage of all feeders is to be kept the same), all the feeder voltmeters in the station will indicate the same voltage although the actual voltage impressed on these feeder circuits may vary widely. If it is desired to hold the load voltage constant at 110 volts on all the feeders, the operator adjusts the feeder regulators so that all the feeder voltmeters at the station indicate 110 volts, making the operation a very simple one. This method will be considered later.

At high power-factors the resistance has a greater effect upon the regulation of the circuit, and the reactance a lesser effect, than at very low power-factors, and *vice versa*. This is illustrated graphically by the curves in Fig. 1, which are based upon resistance volts of 9.85 per cent. and reactance volts of 10.45 per cent. With these values at 70 per cent. power-factor the resistance and reactance have approximately equal effects upon the regulation of the circuit and at approximately this point the drop is greatest for equal values of resistance and reactance.

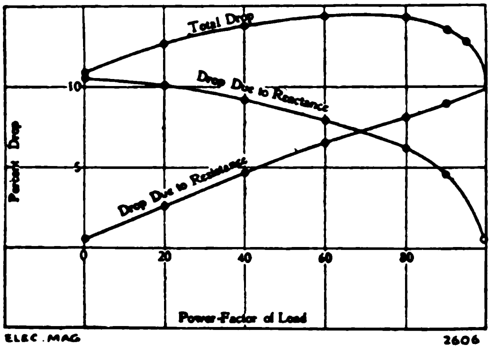


FIG. 1.

The addition of the reactance and resistance drop curves gives the total drop curve.

It will be seen from the curves in Fig. 1 that it is important to compensate for both resistance and reactance drops when the power-factor is even only slightly under 100 per cent. This is more clearly shown by the curves in Fig. 2, the upper curve showing the error for different power-factors with a constant k.v.a. load. In actual practice it would, of course, be very unusual to have a constant k.v.a. output with such a wide range of power-factor as from 70 per cent. to 100 per cent. The power-factor usually decreases as the load becomes less, and by assuming that at 20 per cent. of normal load the power-factor is 80 per cent., at 40 per cent. load it is 85 per cent., and so on, and that a compensator for resistance drop only is used, then the lower curve in Fig. 2 is obtained, which shows that in this case there is an error of 2.5 per cent. at 90 per cent. power-factor. This error would be greater for greater loads at the same power-factor. It will therefore be seen that a considerable error may occur in the compensated voltmeter reading if resistance compensation only is used. If the proper reactance volts were introduced into this voltmeter circuit and the ohmic adjustment set for 9.85 per cent. in place of 10.3 per cent. the errors in curves (Fig. 2) would entirely disappear.

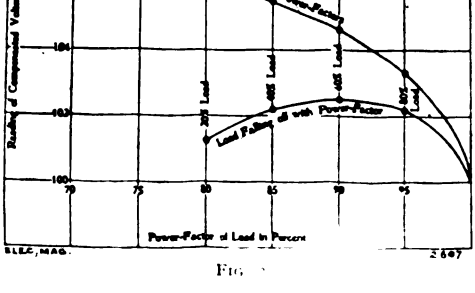


FIG.

Mr. Ralph D. Mershon worked out, in the early days of alternating-current, a novel scheme of introducing into the station feeder voltmeter circuit a resistance drop and a reactance drop equal in per cent. to those of the line, thus producing a voltmeter circuit at the station which would coincide with the actual line circuit. This was slightly modified later in the form of a compensator shown diagrammatically in Fig. 3. This diagram shows secondary windings giving 24 resistance and 24 reactance volts compensation with five amperes in the circuit. In this diagram *C* is a potential transformer delivering at its secondary an e.m.f. proportional to and in step with the station e.m.f. *S* is a series transformer producing in its secondary circuit a current proportional to and in step with the main line current. *A* is a non-inductive resistance and *B* is a reactance coil.

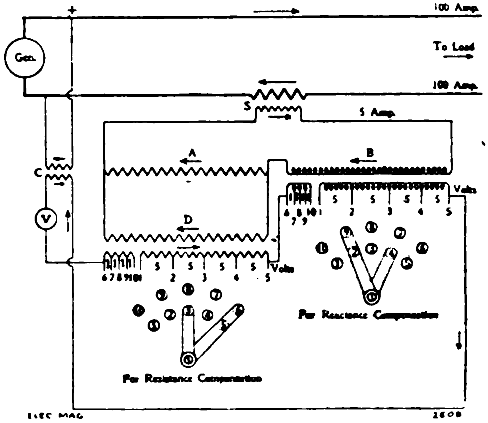


FIG. 3.

A and *B* are connected in series and through them passes the current from the secondary of *S*. The e.m.f. between the terminals of *A* is, therefore, always in step with the back e.m.f. due to resistance of line, while that between the terminals of *B* is in step with the back e.m.f. due to reactance of the line. *D* is a transformer connected in shunt to *A* and yielding at its secondary terminals an e.m.f. in step with and proportional to that across *A*. *B* has a secondary winding on it, so that it fulfils the double function of a reactance coil and a transformer, thus insulating the voltmeter circuit from the feeder.

B and *D* are each provided with ten leads which are carried out to switch contacts, permitting the resistance and reactance volts introduced into the voltmeter circuit to be varied at will. With the proper amount of resistance and reactance volts introduced into the voltmeter circuit the desired result is obtained, since there is from *C* an e.m.f. proportional to and in step with that of the generator, and from *D* and *B*, e.m.f.'s in step with and proportional to the back e.m.f.'s due to resistance and reactance of the feeder circuit. The e.m.f.'s from *D* and *B* diminish the e.m.f. from *C* in exactly the same way and by exactly the same percentage as the back e.m.f.'s in the main line diminish the voltage from the station. The voltmeter will therefore always give an indication proportional to the voltage delivered to the load.

The switch levers should be set so that at the rated current of the series transformer which is connected to the compensator the resistance and reactance in the voltmeter circuit will be equivalent to those of the line. Since both the resistance and reactance voltage of the compensator is exactly proportional to the current flowing (the same as in the line itself) the compensator, when set for the same resistance and reactance volts as that of the line at the rating of the compensator series transformer, will furnish the proper compensation under all conditions of load and power-factor.

SWITCH SETTINGS FOR VARIOUS COMPENSATORS.

Switch Points	Per cent. Compensation of Compensators having a Maximum of			
	6 per cent.	12 per cent.	24 per cent.	36 per cent.
5- 6	.0	.0	0	12
5- 7	0.25	0.5	1	13
5- 8	0.50	1.0	2	14
5- 9	0.75	1.5	3	15
5-10	1.00	2.0	4	16
4- 6	1.25	2.5	5	17
4- 7	1.50	3.0	6	18
4- 8	1.75	3.5	7	19
4- 9	2.00	4.0	8	20
4-10	2.25	4.5	9	21
3- 6	2.50	5.0	10	22
3- 7	2.75	5.5	11	23
3- 8	3.00	6.0	12	24
3- 9	3.25	6.5	13	25
3-10	3.50	7.0	14	26
2- 6	3.75	7.5	15	27
2- 7	4.00	8.0	16	28
2- 8	4.25	8.5	17	29
2- 9	4.50	9.0	18	30
2-10	4.75	9.5	19	31
1- 6	5.00	10.0	20	32
1- 7	5.25	10.5	21	33
1- 8	5.50	11.0	22	34
1- 9	5.75	11.5	23	35
1-10	6.00	12.0	24	36

In order to calculate the amount of resistance and reactance of the circuit for which it is desired to adjust a compensator, it is necessary to know the size of the wire, the alternations, the distance between the compensator and centre of distribution, &c. Accurate information of this kind is usually not readily obtainable. Furthermore, in nearly all cases current is taken from the feeder circuit at various points between the compensator and centre of distribution, thus making it still more difficult to calculate accurately the resistance and reactance of circuits. Using these calculated values for setting compensators without a thorough knowledge of their workings often results in a loss of confidence in the compensator. Very confusing readings may be indicated on the compensating voltmeter when the power-factor changes if the compensator is not properly adjusted. It is strongly recommended that compensators be adjusted by trial. It is of little importance what the reactance and the resistance of the circuit at the current corresponding to the compensator rating is, so long as the compensator has sufficient range for the circuit in question.

The curves of Fig. 4 show the indications of the compensating voltmeter for power-factors ranging between 70 per cent. and 100 per cent. with improper settings. Although in all cases considered in this diagram the compensator was set so as to cause the compensated voltmeter to read correctly, or 100 volts, at 100 per cent. power-factor, it gave incorrect readings at lower power-factors. The upper curve is plotted by assuming the compensator set for 5 per cent. reactance drop, or approximately half the true reactance drop in the line, thus causing the compensated voltmeter to indicate too high readings at less than 100 per cent. power-factor. The lower curve is plotted by assuming the compensator set for 15 per cent. reactance or 50 per cent. more than the proper amount, thus causing the compensated voltmeter to indicate too low readings. The two smaller curves show the voltmeter indication assuming that the power-factor becomes less as the load decreases. Here it is assumed that the load is 20 per cent. of normal when the power-factor drops to 80 per cent.

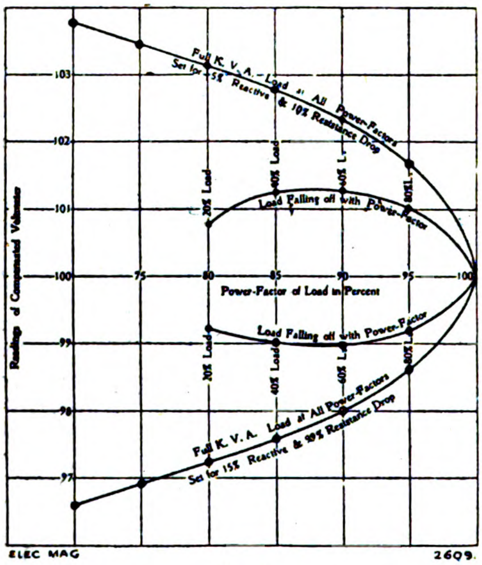


Fig. 4.

The following procedure is recommended for setting compensators by trial: Telephonic communication should be established between the station and the point at which the voltage is to be kept constant. When the load having the highest power-factor is being carried by the feeder (this will usually be at maximum load) the station e.m.f. should be adjusted until the proper voltage is being delivered to the load. At this time the switches on the resistance and reactance sides of the compensator should be set on points which will give the same reading on the compensated voltmeter as does the voltmeter at the load, the switches on the resistance and reactance sides being set at similarly numbered points. This setting would then be correct for all loads if the power-factor did not change. The power-factor will probably decrease as the load becomes less, and if at loads of lower power-factor the compensating voltmeter indicates a higher voltage than that at the load, not enough reactance is in the voltmeter circuit, and hence it will be necessary to increase the reactance until the two voltmeters read alike. If at loads of less power-factor the compensating voltmeter indicates a lower voltage than that at the load, too much reactance is in the voltmeter circuit, and it will be necessary to cut some of it out until the two voltmeters read alike.

The above adjustments should preferably be made at the maximum and minimum power-factors. If the first setting is made at a load at about 100 per cent. power-factor it will not be necessary to change the resistance adjustment at all, for the reason that any change which is made in the setting for reactance at the low power-factors will have very little effect on the compensating voltmeter at high power-factors and *vice versa*. After adjusting the reactance at the lower power-factor the readings of the two voltmeters should be checked when the load having the maximum power-factor is again being carried by the feeder, and if the voltmeters do not read alike adjustment should be made on the resistance side only until they do read alike. This process may be repeated until the compensated voltmeter indicates correctly at all power-factors.

It is not necessary even to remember whether reactance should be added or taken out of the voltmeter circuit if the voltmeter reads too high or too low at low power-factor; all that is really necessary is to simply make all the adjustments on the resistance side for high power-factors and all the adjustments on the reactance side at low power-factors.

In adjusting a compensator time will be saved if at several points, say minimum and maximum loads and one intermediate point, readings be taken of the voltage, which must be impressed on the feeder circuit in order to secure normal voltage at the load. This may require a second voltmeter at the station end, but after these readings have been taken adjustments of the compensator may be made without making a second set of observations at the load. Many stations have and use a curve or table indicating the voltage to be impressed on the various feeders for different loads, which makes the adjustment of compensators a very simple matter.

If compensators are properly adjusted for the circuits in which they are installed they will cause the station feeder voltmeters to indicate correctly the voltage at the load regardless of what the load or power-factor may be. If satisfactory results are not obtained it may be due to one or more of the following reasons:—

1. The connections may be such that the voltage generated in the compensator may be added to the voltage of the potential transformer, thus causing the compensated voltmeter to indicate a voltage higher than that at the station. This is corrected by

simply reversing either the primary or secondary leads to the voltmeter potential transformer, thus causing the voltage generated in the compensator to oppose that of the secondary of the potential transformer. To determine if the connections are correct put the switch points on contacts *5-6* on both the resistance and reactance sides of the compensator. If the voltmeter indicates a lower voltage with the switches on points *5-6* (compensator winding cut out) than it does with them on points *1-10* (compensator winding all cut in) the compensator voltage is not opposing that of the potential transformer and the leads to the potential transformer should be reversed.

2. The voltmeter at the load and the compensated voltmeter may not be calibrated alike. They should indicate alike with no load on the circuit and the switches on points *5-6*. If the load cannot be taken off the circuit to check them they may be intercompared by means of a standard voltmeter.

3. The compensator may not have sufficient range of adjustment for the circuit in question. This may be quickly checked by putting the switches on points *1-10* on both the resistance and reactance sides. If now the compensated voltmeter indicates higher than the voltmeter at the load the compensator is too small for the circuit and one having a greater range will be required. On account of the large number of very small steps on compensators of this type (and the fact that the cost would not materially differ) it is advisable to install compensators having a range of compensation considerably greater than that which is actually required. In selecting compensators it must be remembered that the per cent. compensation marked upon them does not mean that they will furnish accurately the compensation for any and all circuits in which the line drop is the same as their markings.

The ratings of compensators are on the basis of 5 amperes flowing through them from the secondary of the line series transformers and a voltage at the load such as will give an indication of 100 volts on the compensated voltmeter. For instance, at normal current (5 amperes) the 12 per cent. compensator will deliver to the voltmeter circuit a maximum of 12 volts resistance drop and 12 volts reactance drop. If the normal voltage of the compensated voltmeter is 100 then this will represent 12 per cent. resistance compensation and 12 per cent. reactance compensation, and this compensator would compensate for a line drop of approximately 12 per cent. at zero power-factor and also at 100 per cent. power-factor. At points between these limits it would compensate for greater line drops, and at 70 per cent. power-factor it would compensate for approximately 17 per cent. line drop. If, however, the voltage of the load is such as to require compensated voltmeter reading of say 120 volts in place of 100 volts, then the compensation would be 100 ÷ 120 × 12 per cent. or 10 per cent. for both resistance and reactance drop. At 120 volts the ability of the compensator to compensate for line drop would therefore be reduced considerably at all power-factors.

From the above it will be seen that a 12 per cent. compensator designed for use normally on a 100 volt circuit will not compensate for 12 per cent. line drop at 100 per cent. power-factor if the voltage of the compensated voltmeter is greater than 100 volts. Moreover, it will not compensate for 12 per cent. line drop even if the compensated voltmeter is operated at 100 volts, unless with this line drop the current transformer is delivering 5 amperes or more to the compensator.

A compensator should be selected to suit the resistance and reactance of the line. For instance, there might be a condition, especially in high frequency circuits, where the resistance drop is, say, 11 per cent. and the reactance drop 15 per cent., in which a 12 per cent. compensator would give correct voltmeter reading at 100 per cent. power-factor for the reason that the reactance setting has little effect on the voltmeter reading at this power-factor, but it is evident that it could not be set properly for this circuit if the power-factor were much lower than 100 per cent. The simplest and easiest way of adjusting compensators is by trial and not by calculation.

In cases where power is taken from the feeders at different points, the centre of distribution sometimes shifts, causing a slight error in the indication of the voltmeter. This shifting of load from one side to the other side of the point at which the voltage is to be kept constant is usually unimportant and, except in very rare cases, the indication of the compensated voltmeter may be used satisfactorily for adjusting the feeder e.m.f. —*Abstract from The Electric Journal.*

VARIABLE-SPEED COMMUTATING-POLE MOTORS.

A. G. ELLIS.

THE confidence with which it was generally proclaimed a few years ago that the employment of commutating poles removed all the disabilities to which continuous-current machines had been subject, has finally given place to a more guarded attitude in dealing with the design of such machines. Commutating poles are in certain legitimate fields and types the correct and most satisfactory solution to the commutation problem, but the very extensive application which accompanied their recent revival is not justified.

The impression that commutating pole designs permit of radical departures from standard lines of designs resulting in requiring less careful designing and in reduction of cost, is not borne out by a theoretical investigation of the subject nor by the results obtained.

Commutating poles are an unnecessary addition to machines which have good commutation qualities when designed on ordinary standard lines. It is better practice, wherever possible, to obtain good commutation by careful designing than by employing less careful designing and trusting to interpoles to take care of the commutation.

There are, however, certain classes of machinery where interpoles, or some similar commutating device, are a necessity in order to obtain good commutation. Such machines should, however, be designed carefully on standard lines with a view to obtaining as good commutation as practicable, and the interpoles should then be added to ensure satisfactory commutation.

Variable-speed motors constitute one class of machine to which interpoles are a useful adjunct on account of the commutation difficulties encountered at the higher portions of the speed range. Such machines, when the variation is effected by shunt field circuit control, must be proportioned for the heavy flux corresponding to the lowest speed.

At the lowest speed the iron parts of the magnetic circuit are saturated, but at the highest speed, when the field is very weak, the flux densities are very low and the iron sections are much larger than are required to carry the flux corresponding to the high speed.

Thus, for the case of the 40kw., 200 to 1000r.p.m. continuous-current motor outlined in Fig. 1, the flux per pole at 200r.p.m. is 7.5 megalines, while at 1000r.p.m. it is only 1.5 megalines. In order to carry this flux at the densities that correspond to 7.5 megalines, the magnetic circuit for the higher speed need only be one-fifth the cross-section at all parts. Thus, an armature of one-fifth the net core length and magnet cores of one-fifth the section would be sufficient. Such a machine is diagrammatically outlined in Fig. 2, which machine is of sufficient size for an output of 40kw. At 1000r.p.m. a normal design for this rating and speed would, however, be proportioned more on the lines of the outline in Fig. 3.

It is quite possible to obtain either of the designs in Figs. 2 and 3 without interpoles and with good commutation. When, however, the machine outlined in Fig. 1 is running at 1000r.p.m. the commutation is poor at this high speed, owing to the reactance of the great lengths of conductor embedded in the armature core. When running at 200r.p.m., the commutation is good, as the speed is so low, and the design is in all respects as regards commutation not an abnormal design for this speed.

The following tabulated statements of the reactance voltages permit of a good com-

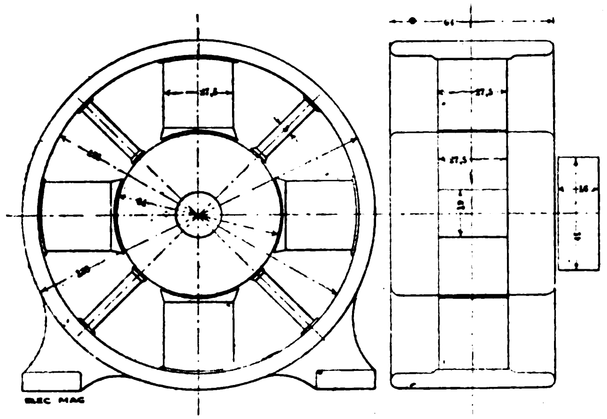


FIG. 1.

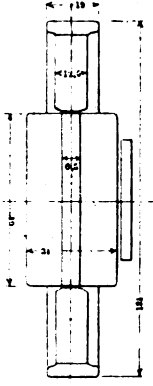


FIG. 2.

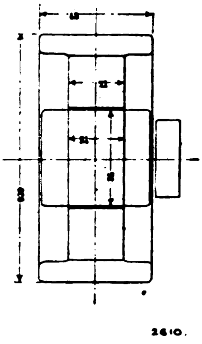


FIG. 3.

parison of the commutating qualities in these various cases :—

Design.	a (Fig. 1).	b (Fig. 1).	c (Fig. 2).	d (Fig. 3).
R.P.M.	200	1000	1000	1000
Reactance voltage	1.66	8.3	2	1.5

While a reactance e.m.f. of 1.66 volts, as in design (a), is not sufficient to require interpoles, the reactance e.m.f. of 8.3 volts at 1000 r.p.m. is far too great for the machine to commutate satisfactorily without resort to interpoles or some equivalent means.

With motors for a smaller range of speed variation, the reactance voltage at the highest speed does not reach such a high value as in the present case, and, consequently, the commutation difficulties are not so great.

In designs where interpoles are required, there is a tendency to cheapen the design by employing even higher reactance voltages than are at all necessary. This is a consequence of employing comparatively few commutator segments, weak fields and many armature turns. In a design of this kind, the whole dependence for commutation is placed on the interpoles. In machines designed on these lines a new difficulty is encountered. This relates to flashing over at the commutator, due to the distorting effects of the armature m.m.f. on the main field. This distortion is greater the weaker the field m.m.f., as compared with the armature m.m.f. Hence, when a variable-speed motor is running at its highest speed with the field weakest, the liability of flashing over is the greatest. A motor with a wide speed range may have at certain points of the commutator an e.m.f. per segment several times the average voltage per segment, and between certain points there may exist a voltage much greater than the actual terminal voltage.

These occurrences are illustrated in the curves of Figs. 4 to 9. The curves of Figs. 4, 5 and 6 relate to the lowest speed of 200r.p.m., and the curves of Figs. 7, 8 and 9 relate to 1000r.p.m., and apply specifically to the 40kw. motor. This motor is designed with four poles and with 471 commutator segments. The machine being operated at 500 volts, the average e.m.f. per segment amounts to 4.25 volts.

This is a reasonably low value at the lowest speed ; that is, at 200r.p.m. The m.m.f. due to armature interference is then only able to slightly modify the m.m.f. emanating from the field spools, and the maximum voltage per segment is not greatly in excess of the average voltage; that is, it is not greatly in excess of 4.25 volts. From the curves in Fig. 5, it is seen to be approximately 8.5 volts.

While the armature m.m.f. is the unimportant component of the total m.m.f. at the lowest speed, namely, 200r.p.m., it is the m.m.f. of the field spool, which is the unimportant component of the total m.m.f. at 1000r.p.m., the highest speed so far as concerns the maximum gap density. This comes about as follows: The field spool m.m.f. at 200r.p.m. is 5520 ampere-turns per spool, and the armature m.m.f. per pole, when supplied with energy at 500 volts and delivering 40kw., amounts to 4710 ampere-turns. Owing to the unfavourable position of the centre of the armature polarity, that is midway between the adjacent pole tips of neighbouring poles of opposite polarity, the armature ampere-turns per pole are able to affect the resultant flux only to the extent indicated in Fig. 4. The curves in Fig. 4 represent graphically the m.m.f. due to the main pole field windings and the m.m.f. due to the armature ampere-turns. The combination of these two m.m.f.'s gives the curve marked "resultant m.m.f.," which produces the flux distribution in the gap shown by the black line curve in Fig. 5.

The dotted curve in Fig. 5 represents the flux distribution at no-load, which corresponds to the *field m.m.f.* curve in Fig. 4. At no-load the field m.m.f. is, of course, the only m.m.f. present, the armature ampere-turns being zero. The black line curve in Fig. 5 represents the flux distribution at full-load, which corresponds to the curve of *resultant m m.f.* in Fig. 4. The ordinates of this curve are also proportional to the volts per segment. If the flux from each pole were uniformly distributed over the whole of the polar pitch area, the volts per segment would be uniform around the commutator, as indicated by the straight line curve in Fig. 5. As will be seen from Fig. 5 the e.m.f. per segment reaches at no-load a value of 7 volts, or 1.65 times the average, and at full-load a maximum value of 8.5 volts, or twice the average of 4.25 volts.

By integrating the volts-per-segment curve of Fig. 5 there is obtained a curve of commutator voltage distribution, as shown in Fig. 6. This curve shows that the maximum voltage which occurs at certain points is slightly in excess of the terminal e.m.f. of 500 volts.

At the highest speed of 1000r.p.m., the conditions are as shown in the curves of Figs. 7, 8, and 9. Firstly, the field m.m.f. is reduced to a value sufficient to produce a flux of one-fifth that in Fig. 4. Although the flux is reduced to one-fifth, the m.m.f. necessary to produce this flux is reduced to an amount considerably less than one-fifth on account of the decrease in the reluctance of the iron parts of the magnetic circuit (principally the teeth) on account of the decreased flux densities. The armature m.m.f. is, however, the same as in Fig. 4, and is now very great in comparison with the field m.m.f. Consequently the armature has a predominating influence on the curve of resultant m.m.f., as shown in Fig. 7. In Fig. 8 there is derived the resultant flux curve similar to that in Fig. 5. It will be observed that the flux curve is much more distorted at 1000r.p.m. than at 200r.p.m., and the ratio of its maximum to its average value is much greater than in the former case. Thus, the maximum e.m.f. per segment reaches in this case a value of 5.7 times the average e.m.f. per segment, or 4.25 × 5.7 = 24 volts. This value is exceedingly high.

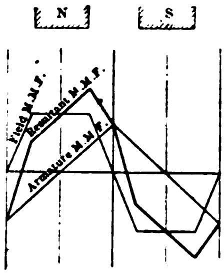


Fig. 4,

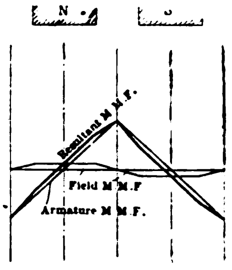


Fig. 7.

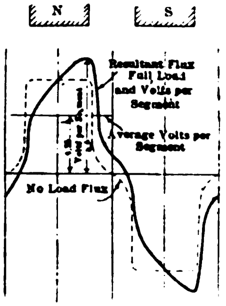


Fig. 5

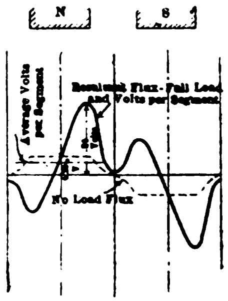
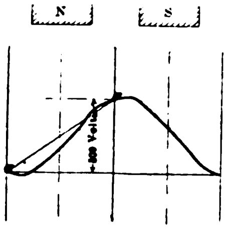


Fig. 8.



ELEC MAG Fig. 6

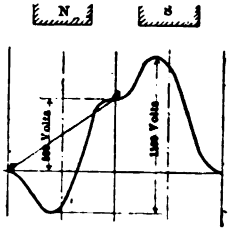


Fig. 9. 2611

In Fig. 9 there is derived the commutator voltage distribution curve from which, on comparison with the curve for 200r.p.m. in Fig. 6, it will be seen that the maximum e.m.f. which occurs is considerably greater, reaching, in fact, about 1100 volts. This is due, as was noted, to the great distorting effect of the armature m.m.f. consequent upon its predominating influence. Such phenomena are most marked when dealing with so wide a speed range as 5 : 1, as the field in such cases is very weak at the

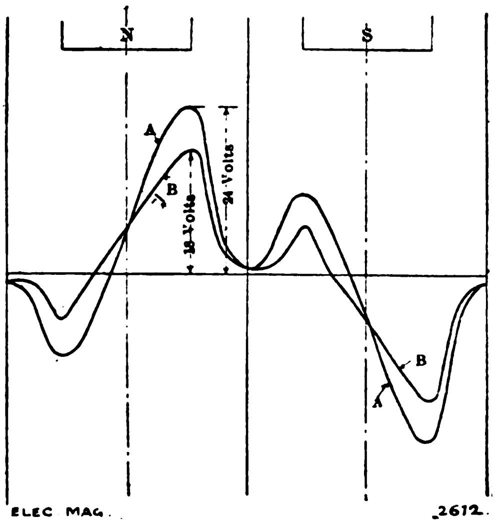


FIG. 10.

highest point of the speed range. With smaller speed ranges, such as 4 : 1 or 3 : 1, the difficulties are not so great, since at the highest speed the armature m.m.f. does not predominate to so great an extent.

The field distortion may be decreased by employing a higher ratio of field m.m.f. to armature m.m.f.; that is, a relatively greater field m.m.f.

For the design considered above, the extent to which the field strength influences the commutator voltage distribution has been investigated, the commutator voltage curves have been derived, using a field m.m.f. twice as great as that employed in the normal design for this motor. The comparison of the two cases is shown by the curves in Figs. 10 and 11, where the curves marked *A* in Figs. 10 and 11 are reproduced from Figs. 8 and 9, respectively. It will be seen that in case *B*, the maximum value of the volts per segment is decreased from 24 to 18, or from 5.7 to 4.3 times the average. Also the maximum commutator voltage is decreased from 1000 to 750. This is still 1.5 times the terminal voltage, and is not a great improvement considering that it has required doubling the field excitation, with a corresponding increase in the amount of field circuit copper and field copper losses.

Attention has already been called to the tendency, when interpoles are employed, to design with weak fields and few segments, with the idea of effecting economy in the construction. From the above conditions, the deleterious effects of such procedure should be obvious.

If in the 40kw. design there had been employed half the number of commutator segments, the average e.m.f. per segment would have been 8.5 volts and the maximum value occurring at 1000r.p.m., 48 volts, which would certainly lead to flashing over at the commutator. It behoves designing engineers to limit the maximum value liable to be obtained by the volts per segment, under any conditions of operation, to a low figure. This leads to many commutator segments and confirms the view put forward repeatedly by the more conservative designers that the use of interpoles affords insufficient reason for abandoning those lines of design which have been demonstrated as sound, but that interpoles should be pressed into service only in those ranges of work where good commutation cannot be obtained by the ordinary type of design, and that when interpoles are employed they should be used in conjunction with good features in other respects. It is useless to evade the fact that this leads to expensive machines. Interpoles are invaluable in many cases, but their use does not lead to cheapness.

Breslauer has stated that good results with interpoles require a wide neutral zone; that is, a small ratio of pole-arc to pole-pitch. It has already been pointed out that the pole shoe of the interpoles should span several slots, and that an interpole machine should have many slots to work well. Every one of

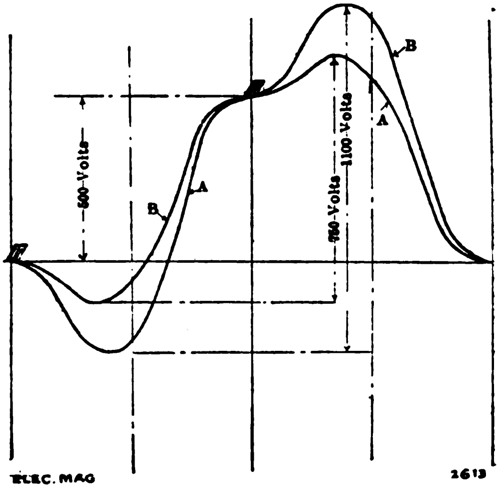


FIG. 11.

these features leads to a design of generous dimensions, and, therefore, it does not tend to lower the cost of machines. It is thus to be hoped that the precipitancy of manufacturers who have committed themselves to interpoles for all their machines, and who, having developed the designs, cannot now draw back, will produce at least the good result of having paved the way for correctly designed interpole machines with plenty of segments, liberal neutral zones, generous pole-arcs for the interpoles, and liberal numbers of slots. These machines will not be cheap machines, but they will, when intelligently proportioned, be high-class machines and there may thus be set up a standard of excellence which, in spite of the higher cost entailed, will come to be regarded as normal.

In conclusion, it may be said that for certain ratings and ranges of speed variation, motors should be built with interpoles, as should also quite a wide range of high-speed continuous-current generators. For less extreme ratings, interpoles may also be used, and with suitable proportions, their use ensures extra high-class results. These proportions, however, entail considerably higher cost, and the claim that for ordinary moderate-speed and low-speed ratings the use of interpoles ensures a high-grade result at low cost, is not borne out by results.—*Electrical World.*

The Testing of High-tension Porcelain Insulators.

THERE appeared recently in *L'Eclairage Electrique* an interesting description of the methods of testing high-tension porcelain insulators at the works of Hermsdorf-Klosterlausnitz, Saxe-Altenbourg, Germany. The laboratory was equipped in 1901 and has been considerably enlarged from time to time. In the tests to which the insulators are submitted particular attention is paid to the arrangements necessary for submitting each part to tests before assembling them; for determining under what tension an arc will pass over the surface of the insulator to the pin, in order to fix the potential for which the insulator is serviceable; and for determining mechanical strengths. There are six testing rooms, one of which is reserved entirely for tests in oil. These tests are made in order to avoid discharges over the surface of the insulators and to determine the potential at which they are punctured. One of the most important tests is that for the resistance of insulation. It is obtained by placing the inverted insulators in water, filling the interior with water, and applying a high potential. All tests are made at a frequency of 50 periods. The current is furnished by four transformers, three of which are rated at 10kw., and will deliver either 50,000 or 100,000 volts. They may be used for voltages up to 150,000 by coupling them in series. The fourth transformer has a rating of 50kw. and its maximum potential is 200,000. This transformer may also be used for delivering currents at 100,000 volts. The first three transformers are placed in one room and the fourth is in a room by itself. Electrical connection between these rooms is provided by means of rods passing through long corrugated porcelain insulators placed in the wall. Screens are placed around these insulators to prevent discharges from striking the wall. Unusual care has been taken in the arrangement of these laboratories to protect the working staff. Each room is divided into two parts by a railing which separates the testing table from the controlling switchboard. Current cannot be turned on to the testing table until this railing is closed; and, on the other hand, this railing cannot be opened until the high tension circuit is itself opened. In addition, a red incandescent lamp is automatically lighted as long as the electrical circuit is closed. When it becomes necessary for an employé to approach one of the testing tables, he wears a suit of woven metallic armour.

Insulators for not more than 2000 volts are tested at six times the pressure for which they will be used, and the test is applied for fifteen minutes, the pressure being maintained constant. If any insulator breaks down during this test, the circuit-breaker automatically opens and at the same time an alarm is sounded. This renders it unnecessary for an attendant to be present during the entire test. Large insulators for high voltages are tested at only double the service pressure.

One room has been arranged for submitting insulators to all sorts of conditions.

By means of pipes a shower of water may be thrown at any angle desired, the room may be filled with steam, or the air may be dried. In addition to this the roof of the building is fitted up for testing insulators under actual atmospheric conditions so as to determine the effects of snow and sleet. A testing machine is provided by means of which the insulators may be submitted to all kinds of mechanical tests, such as traction tests on the pin and horizontal strains on the head of the insulator.

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Electric Tillage.

SOME particulars of the use of electric power for the driving of ploughs are given in a recent number of *The Practical Engineer*, of which the following is an abstract:—

Tillage by electric power has received considerable attention in Italy. The interesting nature of the apparatus employed and the low consumption are points which merit attention. For over twenty years experiments with electric tillage have been made in America and Europe, and in every case the results obtained have been declared satisfactory to a remarkable degree, especially in places where means for the distribution of current already exist for other purposes. It is surprising that the electric plough has not come into more general use; in Austria and Germany there are many installations of this class. It is said that the hundred farms or so owned by the German Emperor are all worked by electricity.

There are two large categories of systems for electric tillage. In the first place there is that in which the plough is automatic and continuous in movement; and secondly that in which the plough has to be hauled along. The first comprises the accumulator systems, those having a current feed and those of the towage type. The second category uses one or two motors; the plough is hauled along by a cable wound upon a windlass actuated by the electric motor. It should be noted that, although the systems in the second class are more expensive and heavier, and require three persons instead of one for their manipulation, they are the systems which are actually employed in all existing installations. As a matter of fact, the accumulator systems are said to have the drawbacks of being too heavy, &c., whilst the systems using a current up-take and towage are said to cause rapid wearing out of the cable passing along the ground. During the course of a lecture read before the Institute of Gembloux, a way was pointed out by which this defect could be remedied by means of an arrangement whereby the cable is always kept taut. So far this system has, unfortunately, not yet been applied.

The system used at Turin is that of the two-motor type. The current at disposal is of the three-phase type, and is supplied through a 25h.p. transformer. The motor of each of the fixed haulage gears or windlasses is of 30h.p., running at a speed of 950r.p.m., and transmitting its power to the drum of the windlass by the aid of reduction gear. The plough used is of the Fowler type, similar to the model employed for steam tilling. The maximum depth to which the shares are able to penetrate is 20in. The plough is guided by the driver (who is seated upon it) by means of a steering wheel. During the course of the trials made the depth of the furrows was only 10in., owing to the bad ground; the travel of the plough being at the rate of 147ft. per minute only. It is only fair to say, however, that the ground was very compact. During the course of another trial the furrows were given a depth of 8in., but the consumption of current increased to 25h.p., whilst when the furrows were given a depth of 10in. the consumption of current was reduced, averaging from 12h.p. to 15h.p.

The current was conveyed to each of the two electric windlasses by means of a cable one kilometre in length, and composed of three 45/10 wires. It was wound up on a reel fitted with wheels. Each of the two electric haulage gears was adapted to run at two speeds, viz., 158 and 238 yards per minute.

The length of the furrows ploughed was about 380 yards. Each run required about eight minutes, including the few seconds necessary to turn the plough round. Hence, if it were possible to work without interruption at this speed, and plough three furrows at a time, it would require about four hours to plough an acre to a depth of 10in.

The working expenses can easily be calculated when the price of the electric energy and wages are known.

ELECTRICAL POWER IN RAILWAY GOODS WAREHOUSES.*

H. HENDERSON.

THE introduction of electrical power into railway working has been of very great assistance, especially in dealing with goods traffic in warehouses. Amongst the chief advantages to be gained are :—

1. More floor space available by making use of overhead travelling cranes.
2. Less aggregate power to perform the same work as hydraulic.
3. Less cost of power.
4. After the machinery is in running order, less maintenance is required.

The Forth goods warehouse of the North Eastern Railway Company, Newcastle, was originally designed for hydraulic power. The total number of hydraulic cranes per row of benches was eighteen, in three rows, making a total of fifty-four. These cranes served benches with an approximate length of 1500ft. and an area of about 48,000sq. ft., which gives 30.3h.p. per 1000sq. ft. of bench area and a lifting capacity of 1.4 tons for the same area.

In the Company's new warehouse at New Bridge Street, Newcastle, which is designed for electrical working, four electric overhead travelling cranes serve two benches of a total length of 580ft. and an area of about 15,000sq. ft. These cranes give 6.13h.p. per 1000sq. ft. of bench area, and a lifting capacity of 0.27 ton for the same area. These figures show what a great saving can be made by adopting such cranes, and that nine similar electric cranes could have replaced the fifty-four hydraulic cranes at the old Forth goods warehouse, where head room is ample for the use of overhead travellers. The figures cover all motions in each case. The types of machinery used in a goods warehouse are :—

1. Machinery for dealing with goods, namely : cranes, hoists, &c.
2. Machinery for dealing with traffic, namely : capstans, hoists, and traversers.

In describing the different types, the new goods warehouse of the North-Eastern Railway at New Bridge Street will be taken as an example, because it has been designed for electrical working, and the whole of the machinery is electrically driven.

Under heading No. 1, a type of crane has been adopted which seems to be most suitable for this class of work. It consists of an ordinary overhead travelling crane, but instead of being fitted with the usual crab, the hoisting gear is attached to a revolving jib carried on a lattice framework fixed to the crab.

The crane has thus four motions controlled by two universal controllers fixed to a platform on the revolving jib. The jib, controllers, and hoisting gear are clearly shown in Fig. 1, which also shows the method of suspension from the crab. The lifting

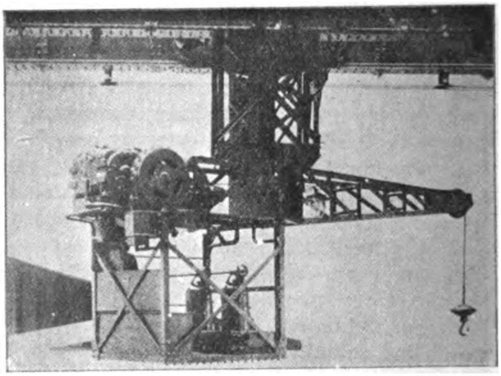

FIG. 1. OVERHEAD CRANE WITH REVOLVING JIB.

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* Abstract of Paper read before the Institution of Electrical Engineers (London) Feby 20th, 1908.

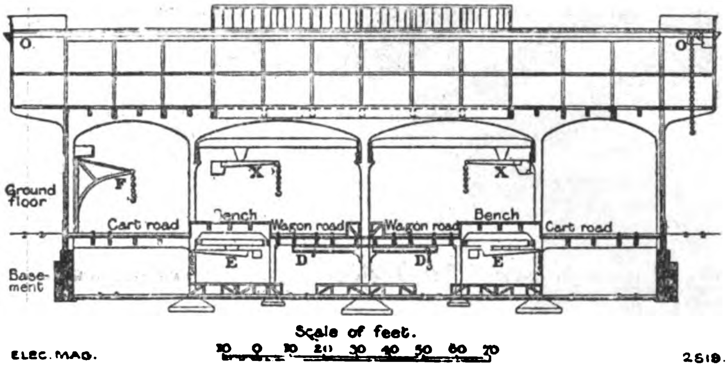


FIG. 2. SECTIONAL ELEVATION OF GOODS WAREHOUSE.

capacity is one ton, and the sizes of the four motors are:—

Lifting motor, 15b.h.p. at 150ft. per minute.
Revolving motor, 1½b.h.p. at 250ft. per minute.
Cross traversing motor, 1½b.h.p. at 150ft. per minute.
Travelling motor, 5b.h.p. at 350ft. per minute.

The span is 48ft. 6in., and the jib radius 11ft. From the cross-section of the building shown in Fig. 2, upon which these cranes are marked X, it will be seen that a jib can reach material outside the span of the main girders and do lifting work in three spans of the main building. This is a great advantage as material can be taken from any wagon and deposited on a cart irrespective of the position of either vehicle. Such work cannot be accomplished by any other type of crane, and at the same time the full command of the whole of the bench is obtained without in any way taking up valuable storage space.

Other cranes on the same floor include two wall cranes shown at F in Fig. 2. These are ordinary revolving jib cranes with stationary machinery and a fixed driving platform. The machinery, consisting of lifting and revolving gear with a separate motor for each motion, is fixed on brackets above the top support of the crane, and the jib is revolved by a vertical shaft carrying a pinion, driving a spur wheel fixed to the top of the crane post. These cranes are capable of lifting one ton at a speed of 60ft. per minute with 6b.h.p., and of slewing at a speed of 150ft. per minute with 1½b.h.p. The motors are driven by a double controller with a single handle, as in use on the travelling cranes.

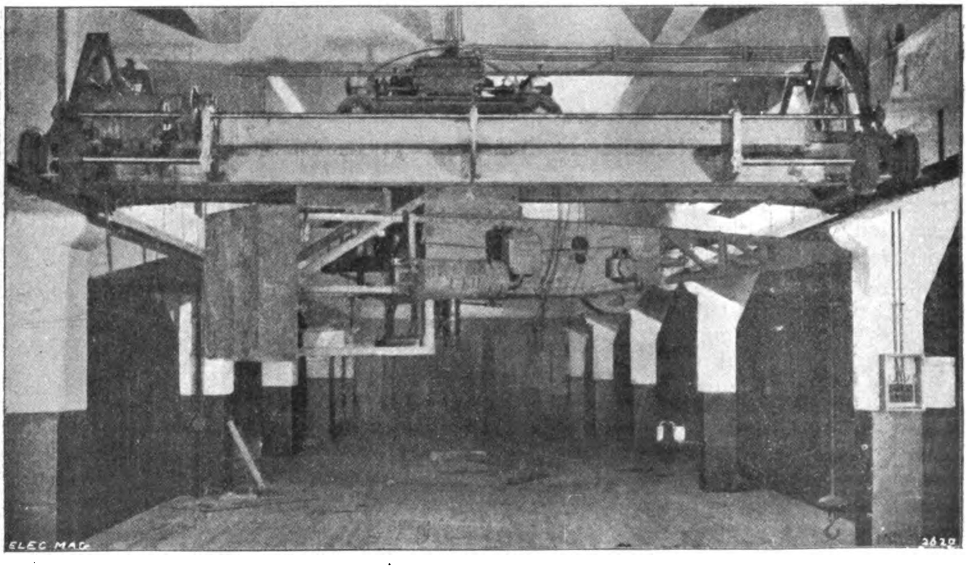


FIG. 3. TRAVELLING JIB CRANE IN WAREHOUSE BASEMENT.

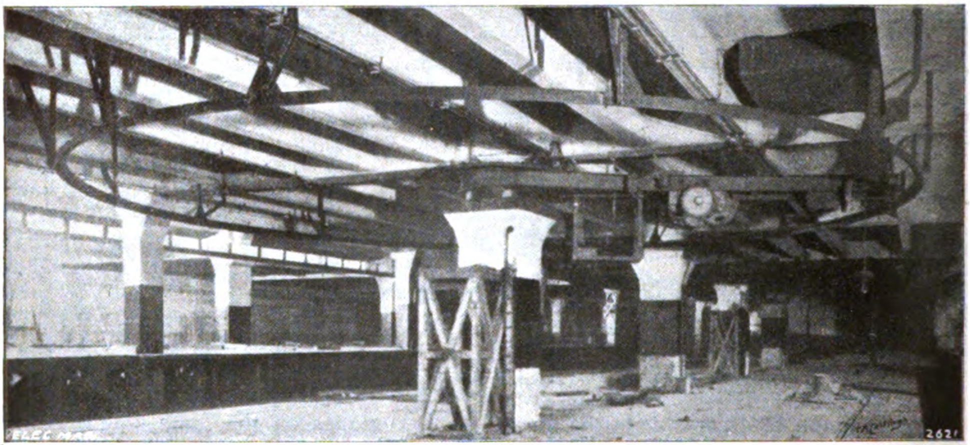


FIG. 4. REVOLVING PILLAR CRANE.

In the basement four cranes have been erected, and owing to the smallness of the head room special types have been used. Two of these cranes are travelling jib cranes, Fig. 3. In these cranes the revolving jibs are 12ft. radius, and the span is 20ft. They can thus cover a width of nearly 40ft. and have a track 200ft. long. The capacity is one ton and the sizes of the motors are:—

Lifting motor, 6b.h.p. at 60ft. per minute.
Revolving motor, 1½b.h.p. at 150ft. per minute.
Cross traversing motor, 1½b.h.p. at 100ft. per minute.
Travelling motor, 2¼b.h.p. at 100ft. per minute.

It will be seen that the hoisting gear is forward on the jib in this case and a heavy balance weight attached at the back. This is done to keep the controlling platform up, on account of the small amount of head room available. The remaining two cranes in the basement are of a special type, and are named revolving pillar cranes. A full view of the crane and circular track is shown in Fig. 4. Each crane consists of a revolving framework, one end of which is constructed to encircle one of the main pillars of the building, whilst the other is fitted with wheels which run on a circular track attached to the roof. The cage and hoisting gear are fixed near the pillar to the revolving frame, and the travelling motor is at the outer end near the wheels, the two motions being driven from one controller. The pillar end of the frame runs on a heavy casting which, when bolted up, forms a vertical circular support carrying a square horizontal flange on the bottom. The end of the frame surrounds this support and carries two rollers which bear on the vertical surface, thus keeping the motion circular. These cranes are capable of lifting one ton at 60ft. per minute with 6b.h.p. and revolving at 150ft. per minute with 1½b.h.p.

For hoisting material to the top floors,

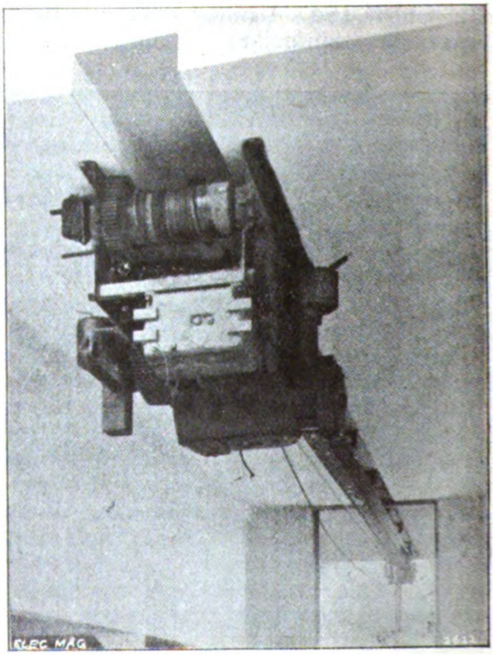


FIG. 5. TRAVELLING CRAB.

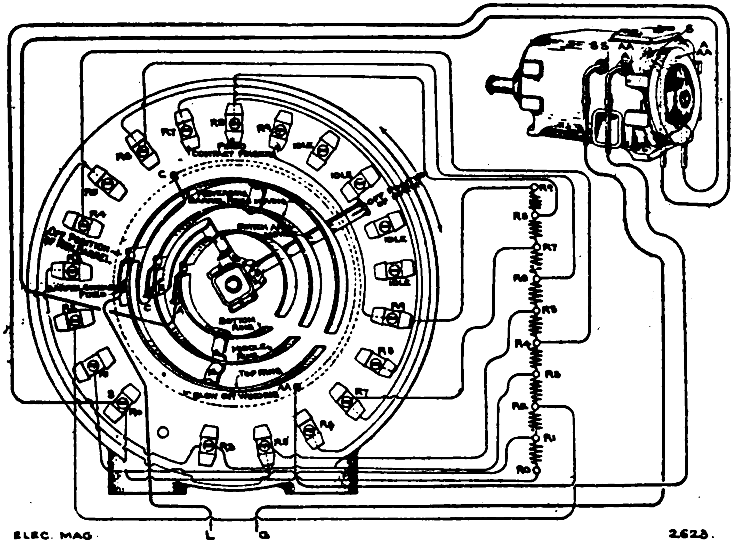


Fig. 6. Connections of Crane Controller.

which are used for storage of grain, flour, and similar materials, there are in use two transporters and six jiggers. The transporters travel the full width of the building at about 70ft. from the ground-floor rail level, the track being extended 16ft. on each side of the building to permit the hoisting of material from wagons outside the warehouse. These machines are shown at O in Fig. 2. The hoisting gear is contained in a travelling crab, which also carries the cage. The track is formed of heavy channel irons bolted to the roof girders and to the concrete roof, the running rails being bolted to the bottom flange. The lifting is done with a 15b.h.p. motor, at 150ft. per minute, and the travelling with 1½b.h.p., at 350ft. per minute, both motors being driven from one controller. The lifting capacity is one ton. These hoists can pick up material from any part of the ground floor directly beneath them, and can deposit it on either of the upper floors, the wire passing through a slot in the floor when travelling from the well to the first floor. In the jiggers the machinery is fixed. A heavy **H**-iron is bolted to the roof, and along this travels a small framework for bringing in the load from outside either to the first or to the second floor, and in two cases to a third floor also. One of these hoists is shown in Fig. 5. The hoisting rope is permanently fixed at one end, to the outer end of the girder, and passes through the travelling frame over two pulleys to the fall block, and thence to the winding drum. The travelling motor drives an endless rope attached to the frame, running it in or out as required. A large pulley is fixed at the outer end of the girder to take this rope. The capacity is 15cwt., and the lifting is done with 10b.h.p., at 100ft. per minute, and the travelling with 1½ b.h.p., at 120ft. per minute. These jiggers are made to be controlled from each floor, and also from two places on each floor, namely, one inside, and one on a platform outside. The various points of working are interlocked in such a manner that the controllers can only be worked from one point at once. This is done mechanically by gear-wheels and clutches, the various points being coupled by wire ropes driving small shafts with bevel wheels, and finally driving two controllers.

All these machines, with the exception of the jiggers, are driven by universal controllers, the diagram of connections for one motion being shown in Fig. 6. The resistances are all enclosed in special iron cases with radiating ribs, forming a compact arrangement easily fixed.

Machinery for Dealing with Traffic.—The capstans, which number forty-two, are designed for a pull of one ton, or six loaded wagons averaging a total weight of about 90 tons, at a speed of 250ft. per minute. The motors are 26b.h.p., and are compound wound, the series winding being on two poles and the shunt on the remaining two. The starting switches are operated directly by the treadle, a strong dashpot preventing too rapid movement of the switch. The switch also contains an overload release, which brings the switch to starting position and necessitates the treadle being released before the motor can be started again. This works very promptly, and prevents rough usage of the capstan. Whether this type of starting switch is the most desirable one for

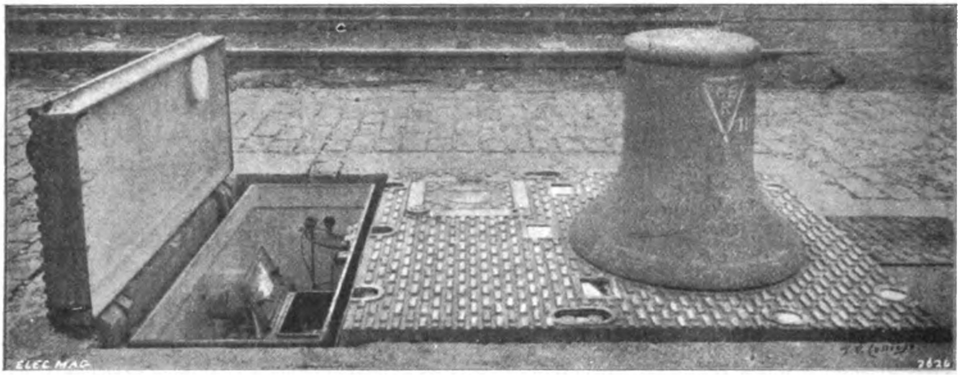


FIG. 7. ELECTRIC CAPSTAN.

electric capstans is a debatable point. Electric capstans cannot be roughly treated as hydraulic capstans can. In the latter, if the capstan is overloaded (a very frequent occurrence), no harm is done to the capstan, and the load must be reduced until the power of the capstan is sufficient for the load before any movement will take place. Such methods of working cannot occur with an electric capstan, and unless a protective device is provided damage will occur to the apparatus. Provided the overload release is kept in order, the operator, however careless, will soon learn that the capstan must be treated with respect if any work is to be got out of it. Another serious objection to the direct operation of the starting switch by the treadle is that the necessity of gradually depressing the treadle tends to take the man's mind off his work, which is by no means without danger; also, owing to his having to work against the dashpot and balance weight attached to the treadle, he may not cut out all the resistance, which will burn out after a few such operations. The preferable method is for the treadle to operate a main switch only, the starting switch being automatically worked either by a magnetic coil or by gearing from the motor spindle. The movement of the treadle then becomes a single one, as in hydraulic capstans. Another point which seems to be overlooked in capstans is the space allowed in the cast-iron tank. Capstans are often designed so small that it is impossible to get into them, and any work on repairs or alterations necessitates working in most awkward positions, where sight of what is being done is almost impossible. This is a great mistake. If the capstan is inside there is no reason why it should not be covered in by light plates, which can be easily removed and the whole of the mechanism exposed. With outside capstans this would not apply, but the difficulty can be got over in a different manner. The author recently had the privilege of seeing several capstans in a goods yard in Lancashire which were excellently arranged. The tank was of a double pattern, fixed end to end, these ends being cut out to form a communication between the two. The tanks were very deep, and one of them was covered with a heavy lid in one piece, which carried the motor and the capstan head. The switchgear was also fixed in the same tank, and consisted of a double-pole switch worked from the treadle, a starting switch from the motor spindle, and a switch which short-circuited the armature when the treadle was off, thus acting as a brake. The second tank was covered with light plates, and simply contained the outlet to the drain, and a ladder for descent. Thus access was easily gained to the capstan proper, and it was possible to pass in underneath the motor and capstan head and do any work required in comfort. All the apparatus was thus under a cover which did not require to be removed, was easily got at, and there was room to deposit any parts which required to be taken down. Objection may be taken to the expense of having to dig a deeper hole for the tanks, but the advantages gained easily outweigh such objection. If all electric capstans were designed upon this principle it would do much to remove a number of the troubles which occur with electric capstans in practical working.

In the forty-two capstans at New Bridge

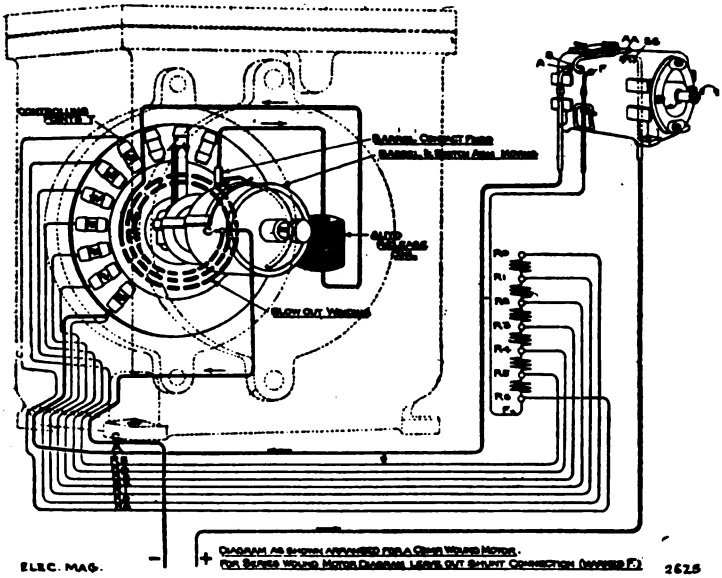

Controlling Fingers
Barrel Contact Piece
Barrel & Switch Arm Moving
Auto Release Coil
Blow Out Winding
A
AA
F
R0
R1
R2
R3
R4
R5
R6
F
−
+
Diagram as shown arranged for a Compound Wound Motor.
For Series Wound Motor Diagram leave out Shunt Connection (marked F.)
ELEC. MAG.
2625

Fig. 8. Capstan Controller Connections.

Street the head is driven by bevel gearing, and the shaft of the armature is fitted with an electro-magnetic strap brake in series with the motor operated for braking by a heavy balance weight when the current is cut off. A view of the capstan is shown in Fig. 7, and a diagram of the connections of the controller in Fig. 8.

Wagon Hoists.—The only access to the basement for railway wagons is by way of the wagon hoists. These are worked electrically, and are capable of lowering 30 tons and lifting 20 tons. They are controlled on the push-button principle, and are probably the largest hoists of that type ever made. The hoisting arrangement is very simple, being, in reality, two sets of huge pulley blocks. The usual method of operation is, however, reversed, and that block which is generally fixed is in this case the movable set, and the load is raised by means of the tail end rope. Its use in connection with a hoist, especially of such a size, is indeed very novel. The machinery, which is at the top of the hoist, is composed of two exactly similar parts, each driven by a 50h.p. 240-volt compound motor, the motors being connected in series. Each motor is coupled to its gearing by means of a shaft carrying a magnetic strap brake and also a high-speed centrifugal brake, to check too rapid motion. The gearing finally drives a large-toothed wheel which has teeth over about three-eighths of its rim, the remaining part being simply flat. The two parts of the machinery are coupled together by means of a heavy crank-pin, forming a complete engine, and leaving a space of about 3ft. 7in. between the large-toothed wheels, in which the ropes are operated. To this crank-pin are attached the ends of the four ropes which hoist the cage, and also the ends of the ropes connected with the balance weights which balance the load. Fig. 9 is a diagrammatic development of the method of attaching the ropes. Starting with the ends, the two ropes are attached to the crank-pin.

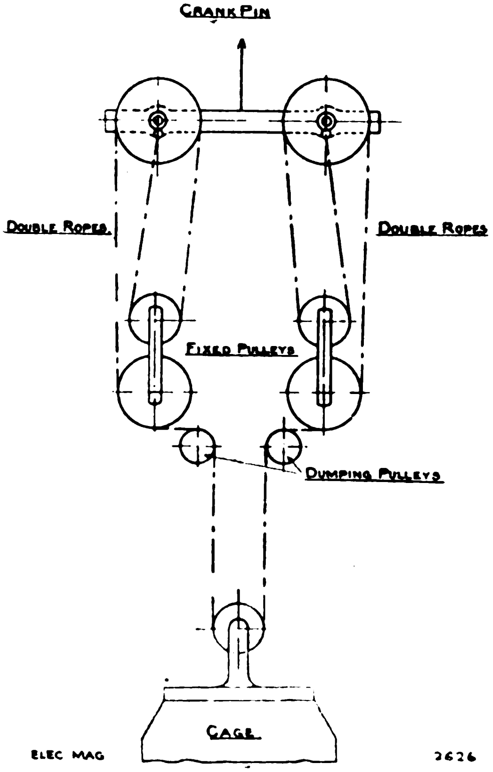


Fig. 9. Rope Attachments for Wagon Hoist.

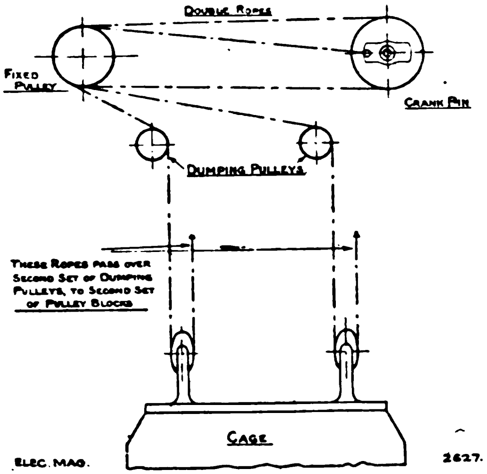

DOUBLE ROPES
FIXED PULLEY
CRANK PIN
DUMPING PULLEYS
THESE ROPES PASS OVER SECOND SET OF DUMPING PULLEYS, TO SECOND SET OF PULLEY BLOCKS
CAGE
ELEC. MAG.
2627.

FIG. 10. ROPE ATTACHMENTS OF WAGON HOIST.

From thence they pass over a fixed pulley at the side (both ropes running in one groove). From this pulley they pass over the pulley on the crank-pin and back to a second fixed pulley, after which they pass over "dumping" pulleys to the top of the cage, the double rope opening out so that they may be attached to each side of the top beam. The ropes then return from the pulleys attached to the cage to the second set of blocks, finally being made off at the opposite end of the crank-pin to which they started. This arrangement is shown in Fig. 10. The switch-gear is of Messrs. Smith and Stevens pattern, operated from push-buttons on the ground floor and from a set of push-buttons in the cage. Fig. 11 shows the connections and the various coils connected with the starting-gear, which is of the makers' usual pattern, enlarged to suit the size of the hoist.

The speed of the hoists is 60ft. per minute and the lift 18ft.

After the wagons are lowered to the basement floor they are received by a large traverser This machine runs in a special pit 30ft. wide and the full width of the building. The traverser consists of a large platform 27ft. long and 18ft. wide, running on eight large grooved wheels on four sets of rails. There are also two sets of roller wheels running on the same rails to take the centre weight and that of the driving platform. Upon one side, which is extended and fitted with a hand-rail, is fixed the motor which drives the traverser, and also a capstan head for drawing wagons on to the traverser from the hoist. The motor is 26b.h.p., driven by a simple reversing controller. The motor drives a shaft fitted with a double-clutch gear. One clutch drives the nearest shaft which carries the running wheels, and the other clutch drives the capstan head. The clutches are operated by one hand-wheel so that both motions cannot be used together. The clutch connecting the capstan head is arranged to drive the head in one direction, the reversal of the motor driving the shaft only, the arrangement being similar to that of a free-wheel. Current is carried to the motor through collectors fixed underneath the floor of the traverser and running in a conduit carrying the bare wires. The speed of the traverser is 300ft. per minute, and the capstan speed 200ft. per minute.

The power is taken from the Newcastle Electric Supply Company's Pandon Dene sub-station at a pressure of 480 volts between the outers. All the power is supplied at this pressure and the lighting at 240 volts. The whole building is controlled from two switchboards, one for power and the other for lighting, a separate account being kept of the energy used for each.

With regard to the cost of electrical working, the New Bridge Street warehouse has not yet been in use to any large extent so that no figures can be given. Some interesting figures are, however, given below with respect to a goods warehouse in the South-West of England. This warehouse origin-

SCHEDULE OF POWER INSTALLED.

	No. of Machines.	No. of Motors.	Power of Machine, b.h.p.	Total Power. b.h.p.
Basement—				
Overhead travellers ..	2	8	11¼	22.5
Revolving pillar cranes	2	4	7½	15.0
Wagon traverser ..	1	1	26	26.0
Wagon hoists	2	4	100	200.0
Capstans	16	16	26	416.0
Ground Floor—				
Travelling cranes ..	4	16	23	92.0
Radial wall cranes ..	2	4	7½	15.0
Capstans	26	26	26	676.0
Second Floor—				
Transporters	2	4	16½	33.0
Jiggers	4	8	11½	46.0
Third Floor—				
Jiggers	2	4	11½	23.0
Total	—	—	—	1564.5

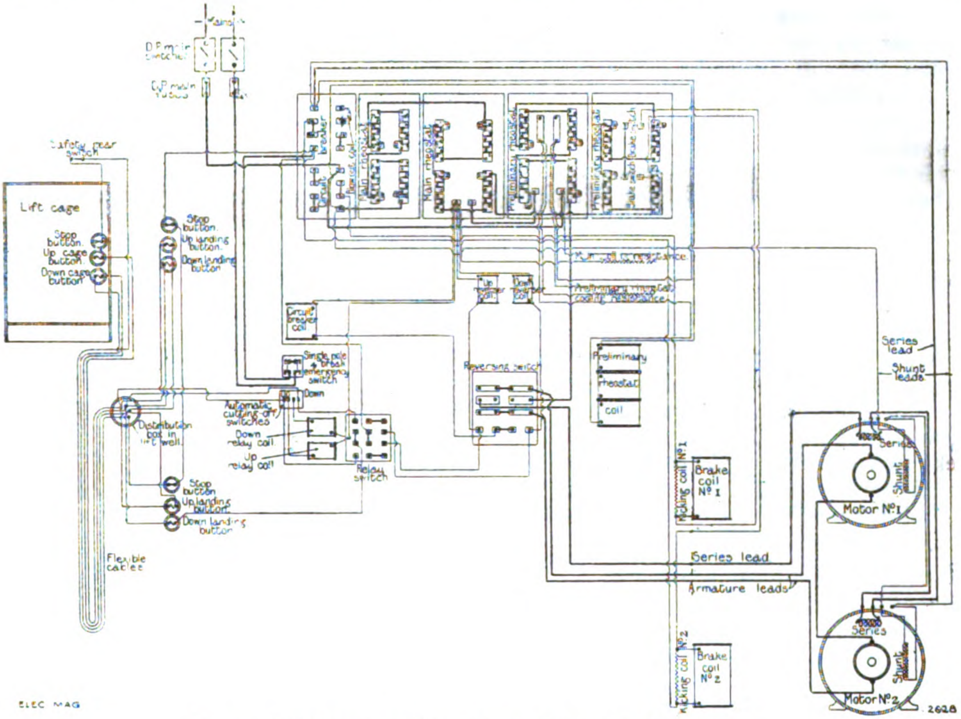


FIG. 11. CONNECTIONS OF PUSH-BUTTON CONTROL OF WAGON HOIST.

ally contained fifty hydraulic cranes and six hydraulic capstans. Before deciding to electrify the cranes, &c., experiments were made to ascertain which cranes and capstans used most of the water. It was found that three of the cranes, and the six capstans, used 90 per cent. of the water. It was then decided to electrify these and drive the remaining cranes with electrically driven pumps. The cranes were electrified by fixing a lifting and slewing gear on a fixed framework underneath the bench, utilizing the old crane posts and jibs. In one case the old hydraulic controllers were used to work liquid starters, in the second crane special liquid starters were fixed, and in the third crane, which was used most frequently, ordinary controllers with wire resistances were used. The two pumps were fitted with 15b.h.p. motors and worked automatically from float switches on the accumulators. By means of change-over switches in the float circuits, the pumps and accumulators could be grouped as desired. These alterations were carried out at a cost of £1157, and the cost of working fell from £600 to £150 per annum. The saving of labour in such cases is very great, especially if the power is taken from a public supply as is done in the case mentioned, the rate being 1d. per unit.

This shows what a great saving can be made by means of electric driving even by converting steam or gas-driven hydraulic pumps to electrically driven pumps, and working these by automatic switches.

◆

Mechanical Power Transmission.

T. E. RYDER.

POWER transmission is given but little thought by the average power user. The subject, however, should be a matter for serious consideration. Investigation along this line has shown that the loss of power by mechanical transmission devices varies from 5 to 80 per cent. of the total power consumed, the average loss being from 30 to 35 per cent., or, in other words, one-third of the power generated is being used to turn non-productive machinery.

A common error is to have the belts too tight. This causes the shafting to bend, and the increased pressure adds considerably to the journal friction. If it is possible, put on larger pulleys, or use a wider belt to increase the working load.

Pressed steel pulleys are preferred to iron pulleys, because they only weigh about one-third as much.

It is estimated that every ton pressure on the bearing, whether by weight or by tension on belt, takes 1h.p. to turn it 250r.p.m.

Shafting out of alignment is the cause of the loss of an immense amount of power. In a new building shafting should be realigned every three months, and great care should be taken, where wood stringers are used, to see that the timber is thoroughly seasoned. The author finds it necessary to line up the shafting in most buildings two or three weeks after the shafting is erected. This is caused by the building settling and the wood shrinking after the heat is turned on in the building.

All modern shaft hangers have both horizontal and vertical adjustment for the bearings. This makes it much easier to accurately align the shafting and to do it in about one-quarter of the time it takes with a hanger having but vertical adjustment. The vertical adjusting screws should be large enough to furnish a rigid support to the bearings.

Hanger frames made of cast iron are preferred to steel frames, because they are much more rigid.

The ring oiling babbitted bearing is the most popular of the self-oiling sliding friction type, because this means of lubrication is the most positive, and more nearly approaches a thorough oil bath. It is, however, a question of lubrication entirely, and while it is the best of this type, it should be carefully watched and the reservoir cleaned at least once a year and refilled with good mineral oil about 250 viscosity. The ordinary standard bearing that requires to be oiled twice a day is used but very little at the present time, the item of time spent in oiling amounting to much more than the increased cost of the ring oiling bearing.

J. F. Springer, in an article on ball bearings which appeared in the *American Machinist and Power*, says: "Probably the great bulk of ball bearings, if we except a few styles made in the last few years, have been constructed on more or less erroneous fundamental principles."

He also says in reference to friction in ball bearings:

"That which arises from the sliding contact of balls with balls is attracting the attention of many inventors. The point should be emphasized that this friction is a sliding, and not a rolling one. A little attention to the subject will convince one that the balls are rotating in opposite directions at the point of their mutual contact. It would seem that the only effective means of eliminating this source of sliding friction is the introduction of a ball or roller, or the equivalent, between consecutive bearing balls in such a manner that the separating means is not in pressure contact with either raceway. A separating device which does not roll would have but little effect apparently as the slide would still remain."

This feature, and because manufacturers have come to realize the necessity of using larger balls, on account of their load carrying capacity, also that it is possible to-day to get steel the hardness and toughness of which has never before been equalled, makes it possible to furnish a bearing giving almost universal satisfaction. This intermediate ball between the load carrying balls is commonly called a double ball bearing. That a tremendous saving of power can be effected by using double ball bearings is generally acknowledged. Various tests made with this type of rolling friction over the sliding friction bearing have shown a saving of over 75 per cent. of the entire shaft friction. These bearings have been in continuous service for seven years; the author examined the bearings in the first mill equipped with them in the New England States, and all of them appeared in perfect condition. In this mill they are running twenty-four hours a day, this service being equal to more than fourteen years in a plant that runs but ten hours a day. Inspection of a bearing that had been running about 350r.p.m. for over three years, revealed absolutely no sign of wear.

The first cost of equipping a plant with modern transmission material is heavy, yet in most cases the cost of such equipment will be wiped out within a year on account of increased savings.

In these days of keen competition it is necessary to take advantage of every means to reduce the cost of manufacture. The saving in power that can be effected in the average plant will reduce the cost of the manufactured article from 1 to 2 per cent. —*Canadian Manufacturer.*

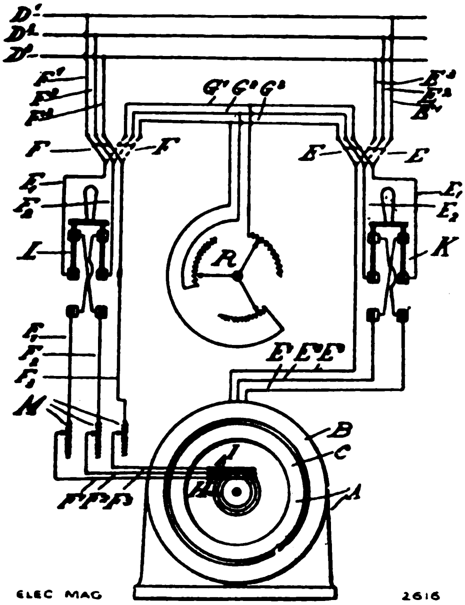


Fig. 1.

A New Variable-Speed Alternating-Current Motor.

A patent has recently been issued in the United States to C. A. Lohr for the invention of an alternating-current motor of the polyphase rotary-field type, the object of the invention being to provide a simple means for changing the speed of the motor and to do away with the changing of the number of poles or the use of different stators or rotors. The invention broadly consists of an alternating-current motor so arranged that its speed may be readily changed, and this will be easily understood from a reference to the accompanying illustrations.

Fig. 1 shows a diagram which indicates the electrical connections used for changing the speed of the motor. The alternating-current motor is represented by A, and B shows the stator and C the rotor. D^1, D^2 and D^3 are main conductors connected with a three-phase alternating-current source, and E^1, E^2 and E^3, when in contact with a double-throw, triple-pole switch, E, energize the stator, three other supply conductors F^1, F^2 and F^3, when in contact with the double-throw, triple-pole switch, F, serving to energize the rotor. Auxiliary conductors, G^1, G^2 and G^3, have interposed therein a regulating resistance, R, and are connected with the switch, E, when thrown as shown in the full-drawn position, or connected with the switch, F, when thrown as shown in the dotted position of the switch.

The arrangement of this alternating-current motor differs from the usual construction in that both parts of the motor generate rotary fields when supplied from the alternating-current source. The speed of these rotary fields may be either the same or different. The speed may be different by the use of a different number of poles in the stator and rotor, or by connecting the stator and rotor each with a source of electricity, each having a different periodicity. Also, the direction of rotation of the rotary fields in the stator and rotor may be the same or different. Two other cases also are possible: Either to generate a rotary field in the stator and connect the rotor with the variable resistance, R; or connect the stator with the variable resistance, R, and connect the rotor with the current supply.

When only the stator is connected with the line, and the switch, F, is thrown so as to make connections with the conductors, G^1, G^2 and G^3, and thus connected with the variable resistance, R, the motor will run asynchronously with the speed of the stator field. When, however, only the rotor is connected with the line, that is, the switch, F, making connection with the conductors, F^1, F^2 and F^3, and the switch, E, thrown so as to make connection with the conductors, G^1, G^2 and G^3, and thus connected with the variable resistance, R, then the motor will run asynchronously with the speed of the rotor field.

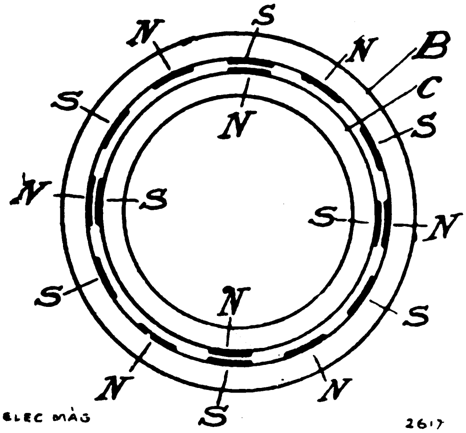
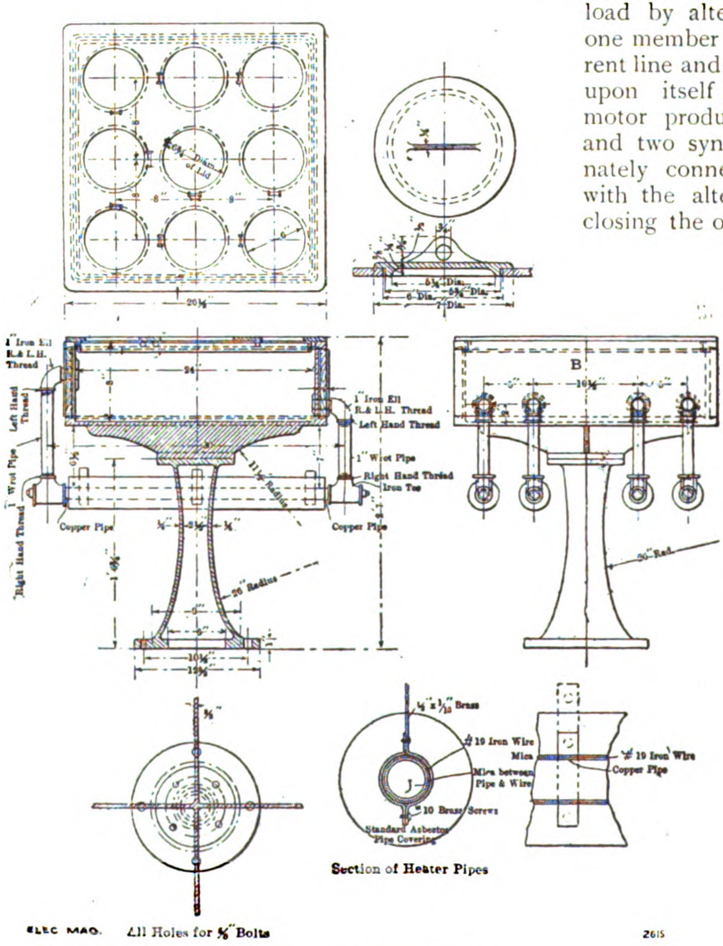


Fig. 2.

When both members, stator and rotor, are simultaneously connected with the line, that is, the switch, E, making connection with the conductors, E^1, E^2 and E^3, and the switch, F, making connection with the conductors, F^1, F^2 and F^3, and when the rotary fields are generated in opposite directions, having properly thrown the reversing switches K and L, then the motor will run synchronously with a speed equal to the sum of the rotary field speeds. When the rotary fields in stator and rotor are generated so as to rotate in the same direction, having properly thrown the reversing switches, K and L, then the motor will run synchronously with a speed equal to the difference of the rotary field speeds.

The general application of this invention, therefore, may be summarized as resulting in the following different types of alternating-current motor: An alternating-current motor producing two speeds, one asynchronous, the other synchronous, by connecting alternately either one member alone or both members simultaneously with the alternating-current line; an alternating-current motor producing substantially a synchronous speed by connecting both members simultaneously with the alternating-current line. These two types of alternating-current motors are obtainable by employing the principles as described, and a motor having the same number of poles in the two motor members. By employing the principles as described and a motor having a different number of poles in the two motor members, the following types of alternating-current motors can be obtained: An alternating-current motor producing two asynchronous speeds obtainable under load by alternately connecting only one member with the alternating-current line and closing the other member upon itself; an alternating-current motor producing two asynchronous and two synchronous speeds by alternately connecting only one member with the alternating-current line and closing the other member upon itself, and by simultaneously connecting both members with an alternating-current line and changing the direction of rotation in the rotary field in one member; an alternating-current motor producing substantially a low synchronous speed equal to the difference of the rotary field speeds in stator and rotor.



AN ELECTRIC GLUE-HEATER.

An Electric Glue-Heater.

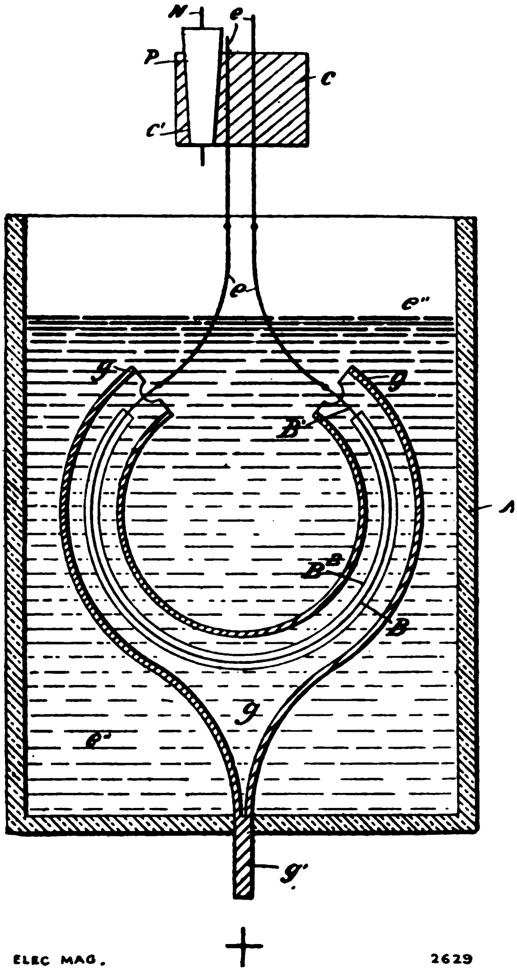
THERE are many novel features in the design and arrangement of a new pattern shop built at the works of the Maryland Steel Company, U.S.A. The original shop was destroyed by fire and the new building was designed and set up complete in working order within eight weeks on the site of the destroyed shop. A full account of the work done and details of the building and its furnishings are given by H. J. Kennedy in a recent number of the *American Machinist.* Of particular interest to electrical men is the method adopted for heating glue.

The power for the machines is, of course, supplied by electric motors and the heating of the building is by hot air, the heater coils being supplied with steam at about 5lb. pressure from the exhaust of a neighbouring plant. There being no steam piping inside the building, electricity has been adopted for heating the glue. There are installed in the shop two electric glue heaters of the company's own design as shown in the illustration. Each of these heaters holds nine pots, the water being kept at a uniform temperature by four circulating loops, the heating surfaces of which are copper pipe encircled by No. 19 iron wires conveying electric currents, encased in mica insulation inside of asbestos pipe covering. The regulation of the stove temperature is effected by hand rheostats.

The Making of Metallic and Metallized Lamp Filaments.

One of the most persistent workers in the development of metallic or metallized filaments for incandescent lamps has been Mr. Cazin, of Hoboken, N.J., who has for over fifteen years been experimenting with different processes for making filaments more satisfactory than the common carbon type. During this period Mr. Cazin has tried almost every conceivable combination of the common and rarer metals alone and with carbon as a core. Amongst the several recent patents taken out by him the following appears to be most noteworthy.

The patents are all very broad and cover the use of quite a variety of metals and alloys. In each case, however, the metals are coated singly or in combination on a filament core by an electrolytic process. A number of distinct layers are provided for. Before placing the filament core into the electrolyte, its surface may be prepared for the deposit of the preferred metals, osmium and iridium, by a primary deposit of zinc, which is then amalgamated with mercury. The zinc and mercury so used are subsequently removed by dissolving or evaporating them off.



Preparation of Carbon-Metallic Filaments.

The diagram of the preferred form of the apparatus used for the electrolytic deposition of the osmium-iridium shows that the two ends of the filament core, as one electrode, are attached to the same pole. The other electrode may be dispensed with in its complicated form, as long as this second pole is immersed into the electrolyte. This electrolyte is prepared by dissolving osmiate of potash with a small admixture of chloride of iridium. It is assumed that the deposition of the two metals is brought about in a secondary reaction, hydrogen being set free and reabsorbed in a double reaction.

One of the features of the invention is the arrangement of a carbon filament to form the negative pole in an electrolytic bath in a loop-shape, similar to the shape in which it is to be used in the lamp, without direct connection with the positive pole, such as is used in the common flashing process. Importance is attached to the form of the metal used as the positive pole in the bath, by which form the carbon loop (B), (B′) is in close opposition or proximity and at mainly uniform distance to and from the plate of metal (g), that acts as the positive electrode or anode, and which plate is continuous in itself and to the positive pole (g′). (B^2) marks the part of the electrolytic deposit which faces the plate directly, the extreme parts of lighter deposits not being marked specially, but being limited only by the line of immersion (e″). (C′) is the connecting plug and (P) is the metallic receiver for the wires (e′) and the plug. The coating so produced is said to be amorphous, tenacious and ductile.

When this osmium-iridium filament is set into an exhausted bulb, and the current turned on at the proper moment, even while completing the exhaustion, or when a virtual vacuum has been effected, and when there is carbon present, aside from eventual evaporation of such carbon, a carburization of metal takes place, and it depends on the proportionate thickness of metal and of carbon whether the carburization takes in the entire carbon part, or all of the metal cover, or leaves some carbon, or some metal, yet intact. The best way to produce this carburization is to slowly increase the current passed through the lamp.

To still further improve this filament, Mr. Cazin proposes to place another electrolytic deposit on this metallic cover, and he selects for this purpose a metal or metals of the "rare-metal" class, of which he names thirty-one members without disclosing the preferred one. The compound filament is entered into the partially exhausted bulb, and is then subjected to a carefully controlled current which causes partial or complete oxidation of the outer metallic coat. The bulb is then sealed.

The compound filament then consists of a carbon core covered in turn by a compound of carbon with osmium and iridium, a layer of these two metals, and finally, on the outside, by a coating of rare metallic oxides. —*West. Elec.*

Telephone Research.

WRITING in a recent number of *Telephony*, K. B. Miller indicates the more urgent improvements which are desirable in telephone apparatus and method. The writer is particularly emphatic in indicating the necessity of a thorough scientific study of telephony, and suggests the direction which such research work should take.

The workers in the practice of telephony are in need of more light. While some splendid scientific work has been done, the fact remains that the methods employed in the advancement of telephony have been largely of the "cut and try" order. Things that have not been thoroughly understood have often been glossed over with inadequate explanations. Results have been secured, to be sure, but perhaps telephonists in particular and the world in general have looked on them with too much complacency.

Strange as it may seem at this late date, telephony offers some almost virgin fields for scientific research, the exploration of which in a truly scientific manner cannot fail to uncover truths which will be of great value.

One notable and recent example of what may be accomplished by the scientific and even academic method of attack is the work of Dr. M. I. Pupin, who developed, by strictly mathematical means, a method of overcoming some of the deleterious effects of electrostatic capacity in telephone lines by interposing inductance coils of certain characteristics at stated intervals. The broad idea was not new, it had been thought of in a general way before, but it took Dr. Pupin and his mathematical analysis to make the idea successful. That it has been successful will be apparent when it is stated that by reason of it telephone conversation may be carried on at greater distances than before and over circuits that cost much less to construct. Dr. Pupin reaped not only the reward of public acclaim but, in a large measure, of money.

As a basis of further work toward the betterment of telephone transmission, we should know more about voice currents and the effect on the ear of the vibrations which they produce. The problem therefore is not wholly one of electricity or physics—it is in large measure physiological. We hear much about the effects of the various frequencies on the quality of sound, but very little about the effect of varying the *phase relations* between these frequencies.

As a specific problem, therefore, the author suggests the study of the wave form of speech currents.

It is becoming more and more apparent that the modern telephone transmitter cannot retain its prestige in the light of physical analysis. It is believed that if the wave form of the telephone current which results from the action of the transmitter could be studied in detail it would be found to utterly fail in the faithful reproduction of the sound waves. Those who have studied telephone transmission know that part of the success in transmission is due not to the instruments or to the line, but to the adaptability of the human ear and mind. In other words, one does not hear all that he thinks he hears in a telephone, but the ear and the mind, taking the context as a guide, supply many deficiencies.

Telephonists feel pretty well satisfied with the receiver as a responding device. Perhaps, however, in the light of more complete knowledge, even this and the many other things used in the transmission system, to say nothing of the circuit arrangements, could be materially bettered in the light of greater knowledge of fundamental conditions.

As an example of one of the many other things that needs to be done in telephony, the partial or complete elimination of what is commonly termed "side-tone" in the receiver, may be cited. This requires an arrangement of the apparatus and circuits such that the telephone receiver at one station will be affected little or not at all by sounds striking the diaphragm of the transmitter at that station, but will be affected in full degree by currents coming over the line from the distant station.

It is gratifying that the largest operating companies and some of the larger manufacturing companies are establishing well-equipped laboratories for the trying out and developing of new ideas. It is doubtful, however, whether in general these laboratories are getting at the bottom of things, so to speak, from the real scientific standpoint. It is perhaps not to be expected that laboratories maintained for strictly commercial purposes should do this to the best advantage. Such work is more often done in universities, and it is from them that much good could come if the proper interest could be aroused. Let the scientist do some of these things primarily for the sake of doing them, not letting the possibility of monetary reward make him feel—as scientists sometimes do feel — that there is anything sordid or ignoble in the achievement.

Electric Power in a Match Factory.

A COMPLETE power equipment consisting of two 300kw. generators and a 110kw. generator direct-connected to high-speed engines, a five-panel switchboard, twenty-four 5h.p. variable-speed induction motors and a number of constant-speed machines for distribution throughout the plant, was recently installed at one of the Diamond Match Company's factories, all the apparatus being designed for a three-phase, 60 periods, 440-volt service. The unusual feature of this installation is the fact that the match machines are each driven independently by a 5h.p, 1200r.p.m. induction motor, twenty-four machines comprising the initial installation. It was shown by careful tests that individual drive in this plant would decrease the required energy at least 1h.p. per machine by eliminating the use of a mechanical speed changer as well as the long countershafts joining the groups of machines.

In the process of forming the matches, seventy-two sticks are made at each stroke by as many cutters. These sticks are then forced into countersunk holes of a plate conveyer from which they project at right angles, similar to the bristles of a brush. The motion of the conveyer is intermittent, depending on the speed of the machine, the travel being just sufficient to preserve a row of holes for each stroke of the cutters. While the sticks are in position in the conveyer they are in turn dipped in molten paraffin and a composition which forms the head. The matches must be dried before packing and to accomplish this end, the conveyer makes a number of loops exposing the matches to fans.

The test showed that 0.65e.h.p. is required to drive the speed changer alone; the machine proper consumes 2.5, 2.7 and 3.4 e.h.p. at speeds corresponding to 160, 194 and 220 strokes of the cutters. Five-h.p. motors were, therefore, chosen as being of the proper size for the work.

MANUFACTURING Progress

A classified list of articles important to Manufacturers will be found in the World's Electrical Literature Section.

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"Dexine."

The Dexine Patent Packing and Rubber Company, Ltd., Stratford, E.

Of the many types of packings and packing material on the market it can be said that the compound known as "Dexine" occupies a distinct position. This material was discovered some twelve years ago. It consists of a definite mixture of vulcanized rubber with other bodies, the product having a hard smooth surface and exhibiting the further properties of a high degree of flexibility and ability to withstand for indefinitely long periods large extremes of temperature. Having the further advantage of lending itself to ready and accurate moulding, it will be obvious that it forms an ideal body for the making of joints on steam and hydraulic mains and moreover for the modelling of valves, rams and other moving surfaces in hydraulic machinery. The "Dexine" specialities are manufactured at the Abbey Lane works of the Company in Stratford, London, E. Some views are given herewith showing the heavy modern

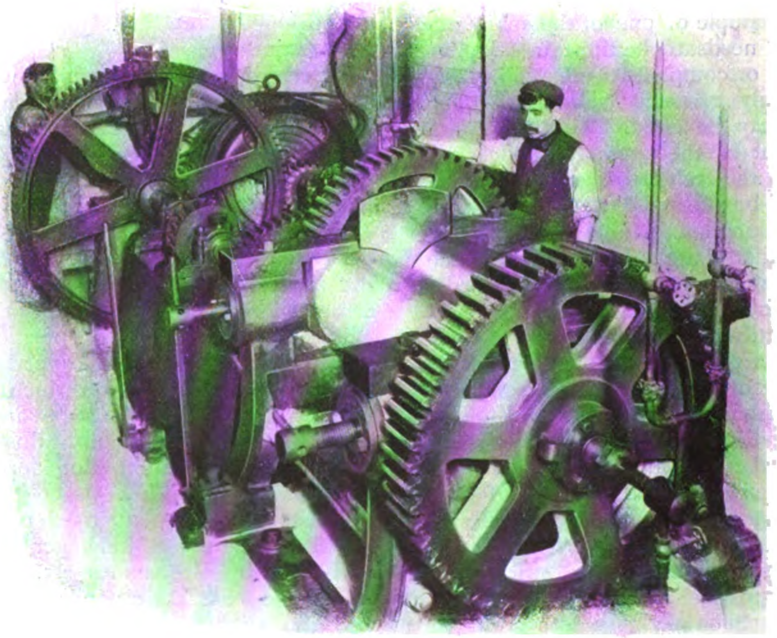


Fig. 1. 80h.p. Motor Driving Rubber Mills in the "Dexine" Works.

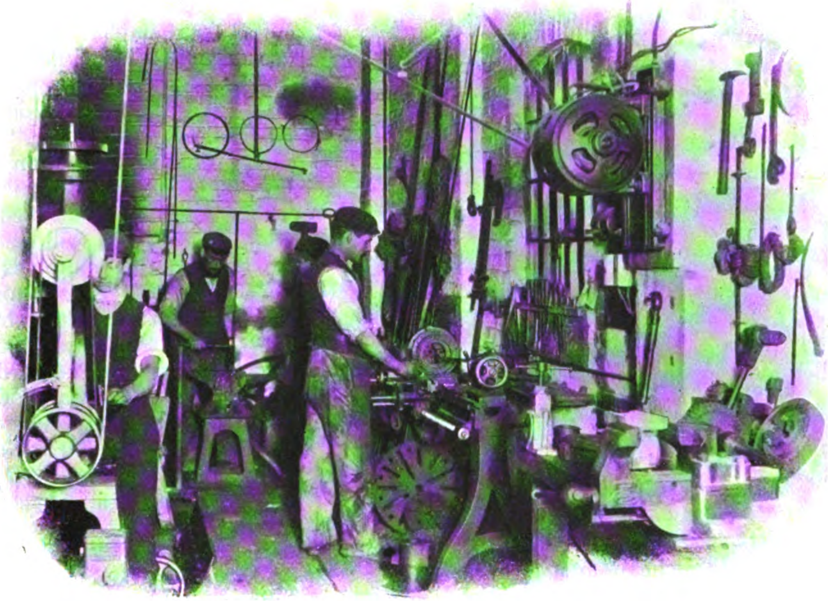


Fig. 2. The Fitters' Shop at the "Dexine" Works

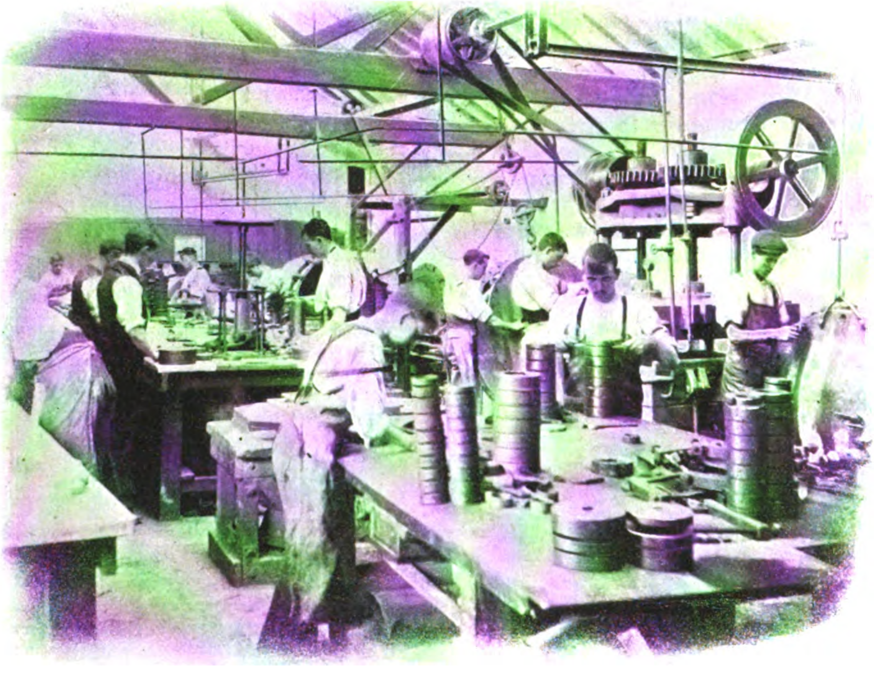


Fig. 3. View in the Moulding Department of the "Dexine" Works.

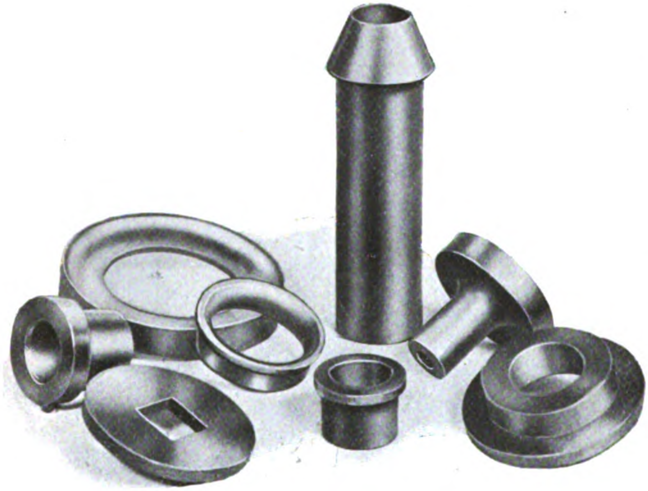


FIG. 4. TYPICAL "DEXINE" PRODUCTS.

equipment which has been put down by the Company for the cheap and accurate production of their several specialities. These works were started towards the end of the year 1896, but in 1905 the business had extended to such proportions that considerable extensions had to be made, and the Company were fortunate in having available a vacant works alongside. This was acquired, fitted throughout with modern machinery, and arrangements were made with the West Ham Corporation for the supply of electrical power to drive the entire new section of the works.

Illustration Fig. 1 shows an 80h.p. motor driving large rolls or mills. This motor, of the three-phase induction type, was the largest to be coupled on the public supply, and although its duty is extremely arduous it is reported that no trouble either inside the works or on the outer supply mains has been occasioned by its steady use. The second illustration shows a 4h.p. motor which provides power for the fitters' shop. It will be seen that the motor is conveniently erected on the wall, transmitting by belt to an overhead line of shafting. The third illustration gives a good idea of the arrangement of the workshop and the ample space and good lighting secured and also the volume and class of work which is undertaken by the Company.

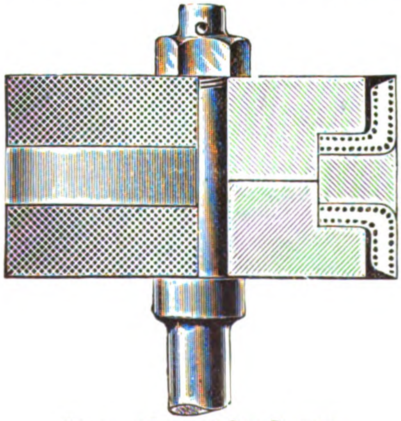


FIG. 5 "DEXINE" RAM PACKING.

As to the "Dexine" products, they cover a very large range. The illustrations Figs. 4, 5 and 6 show some of these specialities. Gauge glass rings and general packings are modelled of "Dexine" only. Where ram buckets, valves, &c., are required the "Dexine" mould is encased in a special anti-friction metallic gauze cover.

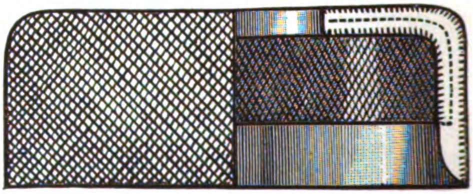


FIG. 6. "DEXINE" PUMP BUCKET.

From the several interesting publications which the Company issues from time to time, there is very full evidence to be gathered as to the remarkable success which follows the use of these specialities. A feature of the "Dexine" productions which should not be lost sight of is that they are of British origin and of British manufacture.

IMPORTANT :—

All Manufacturers who make a speciality of Machinery, Materials, or Appliances for use in ***Iron and Steel Works*** *should send particulars of the same for inclusion in the special IRON and STEEL Number of The ELECTRICAL MAGAZINE. This should be done* ***as Early as Possible,*** *since APRIL 15th is the date of publication.*

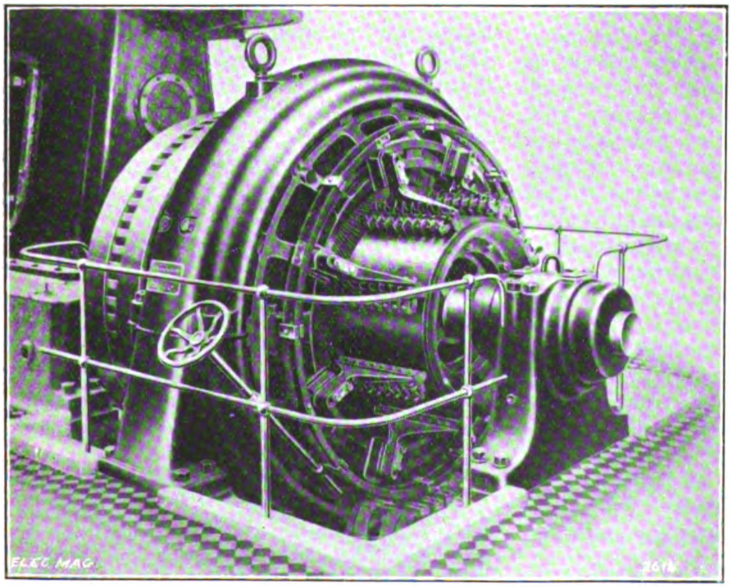
Engine Type Direct-Current Generators.

The British Westinghouse Electric and Manufacturing Company, Ltd.

The latest type of Westinghouse direct-current generator, as shown in the accompanying illustration, embodies many recent improvements. It is designed as suitable for the manifold conditions of industrial plants as well as for those of separate or combined lighting, power and tramway plants and general large distribution systems. With one type of machine the makers therefore claim to meet the numerous requirements common to all services. The following are the more prominent features of the new type which will appeal strongly to the electric power engineer.

Prolonged immunity from breakdown.—To secure this the straight portion of the armature coil, which is embedded in the iron core, and therefore subjected to severe potential stresses, is insulated by means of built-up mica and paper, considerable experience in assembling and treating the coils having shown that this material maintains its high insulating properties.

The commutator is also insulated by strong sheets of mica. An ample leakage distance is provided at both ends of the commutator by the projections of the mica rings.



Westinghouse Direct-Current Generator.

Insulating distance pieces are placed between the field coils and the yoke and poles; and the insulation of the brushgear and terminals receives, likewise, the most careful attention.

Sufficient strength to withstand short-circuits.—The brush-holders, terminals and connections are of a sectional area large enough to enable them to withstand the normal short-circuit current at which the circuit-breakers have to open. Also the frame, shaft, bearings, and bedplate are especially rigid to prevent any damage to the machine when an overload of several times the normal load pulls up the engine.

Overload capacity.—The large overload capacity guaranteed for each machine is obtained by allowing a liberal factor of safety in the electrical and mechanical design. In each individual case this overload capacity is approximately equal to that of the driving engine.

Sudden fluctuations of load can be carried for short periods by utilizing the potential energy of the flywheel. As the machine is well ventilated, a low temperature rise is secured on sustained overloads.

Regulation and Parallel Running.—The voltage regulation of a direct-current generator is chiefly determined by the type of field winding used. The voltage of the shunt-wound machine is regulated by means of a hand rheostat, while the compound-wound machine will either give a constant voltage from no load to full load or a voltage increasing with the load.

To run a machine in parallel with others the field windings must be of the same type, and compound wound machines must have the same increase in voltage from no load to full load.

Efficiency. — High efficiency is obtained at all loads by using sheet iron of the best quality for the armature core. This secures good economy at light loads. The losses in the poles are reduced to a minimum by building the latter of laminated steel.

Sparkless Commutation.—Advantage has been taken of the best proportions of the magnetic and electric circuits in order to secure sparkless running and small wear of commutator and brushes. Sparkless commutation at sustained overloads and over a wide range of voltage is guaranteed. Commutating poles are also employed whenever their use is economical or warranted by special conditions.

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Motor-car Show.

During this month Cordingley's thirteenth international motor exhibition will be held at the Agricultural Hall, London, and will again inaugurate the automobile season so far as the trade is concerned. Although motor-cars have now become familiar sights in the streets, public interest in motor shows has in nowise diminished, and everything points to the forthcoming event, which will open on March 21st and close on the 28th, being as popular as any of the series. Both business and pleasure vehicles will have a large display; not only will many new types of British automobiles be seen for the first time, but several important newcomers are expected from the Continent. The display of heavy vehicles will be as comprehensive as hitherto, and include lorries and vans for ordinary delivery work as well as municipal vehicles and those for public services. The importance attained by the motor-cab and motor-'bus in the traffic of London during recent months gives special interest to this section of Cordingley's exhibition. Among the innovations that will be made is an inventors' section, in which will be given a splendid demonstration of the universal interest with which men of ingenuity are tackling the minor problems associated with the development of the automobile. An aero section will again be a popular feature in view of the recent successes in that field. It is clear that the forthcoming display will again attract thousands of prospective motorists.

NOTE.—Manufacturers are invited to supply particulars of New and Interesting Machinery and Appliances for inclusion in the "Manufacturing Progress" Section of The ELECTRICAL MAGAZINE.

B.A. Meeting, 1908.

The following have been elected by the council of the British Association to be presidents of sections at the meeting of the Association to be held in Dublin in September next under the general presidency of Mr. Francis Darwin, F.R.S. :—Section A (Mathematical and Physical Science), Dr. W. N. Shaw, F.R.S., Director of the Meteorological Office; Section B (Chemistry), Prof. F. S. Kipping, F.R S., Professor of Chemistry in University College, Nottingham; Section C (Geology), Prof J. Joly, F.R.S, Professor of Geology and Mineralogy in the University of Dublin; Section D (Zoology), Dr. S. F. Harmer, Superintendent of the University Museum of Zoology, Cambridge; Section E (Geography), Major E. H. Hills, C.M.G.; Section F (Economic Science and Statistics), Lord Brassey; Section G (Engineering), Mr. Dugald Clerk, M.Inst.C.E.; Section H (Anthropology), Prof. W. Ridgeway, Professor of Archæology in Cambridge University; Section I (Physiology), Dr. John Scott Haldane, F.R.S., University Reader in Physiology at Oxford; Section K (Botany), Dr. F. F. Blackman, F.R.S., Professor of Botany in the University of Leeds; Section L (Educational Science), Prof. L. C. Miall, formerly Professor of Biology in the University of Leeds.

Invitations to deliver evening discourses during the meeting of the Association at Dublin have been accepted by Prof. H. H. Turner, F.R.S., Savilian Professor of Astronomy at Oxford, who will take as his subject "Halley's Comet," and Prof. W. M. Davis, of Harvard University, whose lecture will be entitled "The Lessons of the Colorado Cañon."

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New Catalogues.

Motor Car Accessories.—General Electric Company, Ltd., London, E.C. This Company has just published the fourth edition of Section "O" of their catalogue. This illustrates and gives prices of ignition coils, sparking plugs, accumulators, magneto machines, &c. The range of appliances covered is very wide.

Gre-Solvent.—Beanland, Perkin & Co., Leeds. We have received sample and price list of a material known as "Gre-Solvent" which will doubtless appeal to all engineers. It is claimed that this material will effectually remove any form of grease, paint, tar and metal stains either from the hands or from fabric. It is sold as being specially prepared for engineers, motor-car drivers, metal workers, dyers,

&c., and also for use in the household. We can speak from experience that this material quite serves its purpose.

Wattmeters & Phasemeters.—UNION ELECTRIC COMPANY, LTD., LONDON, S.E. List No 8c08 deals with Wattmeters for both direct and single-phase alternating current circuits, fitted in cases suitable for mounting on switchboards, &c. The list also includes information with regard to neutral point resistances for using Wattmeters on three phase circuits with inaccessible neutral points.

An interesting apparatus also described is the direct reading Phasemeter which indicates directly the phase angle between current and pressure in an alternating current circuit.

Alternating Current Arc Lamps.—UNION ELECTRIC COMPANY, LTD., LONDON, S.E. List No. 1345 deals with Enclosed and Kohinoor patterns of arc lamps for alternating current circuits. These lamps possess all the mechanical and electrical advantages of the well known "E.V." and "Kohinoor" arc lamp, for direct current circuits, with the necessary modifications to make them suitable for alternating current working.

The list also includes prices of line resistances, transformers, globes and reflectors, and various suggestions with regard to circuit arrangements.

Factory Lighting.—UNION ELECTRIC COMPANY, LTD., LONDON, S.E.—Under this title the Union Electric Company have published a little book explaining in general language the industrial advantages of good artificial lighting. Every manufacturer and electric lighting contractor should write for a copy of this circular.

Vulcanised Fibre.—ARTHUR CORT & CO., CAMBERWELL ROAD, LONDON, S.E.—Wholesale price list of red, grey or black insulating hard or flexible vulcanised fibres. This material is supplied in sheets, tubes, or rods, and also moulded in washers, valves, etc. The Company also supplies balata, gutta percha and cotton beltings, of which particulars and prices are given.

Flexible Conduit.—GRATZE PATENTS & ENGINEERING SYNDICATE, LTD., LONDON, W.C. —Small illustrated folder, giving sizes and prices of a new flexible non-metallic conduit, known as "Flexduct." "Flexduct" is an interwoven conduit claimed to be indestructible, tough, and of high insulating qualities. It has a perfectly smooth interior, unaffected by kinking or crushing.

Small Motor Generators, Motors, &c.—THE CRYPTO ELECTRICAL COMPANY, LONDON, S.E.—Illustrated price list giving details of a useful line of small A.C. and D.C. converters and motor generators as particularly suited for accumulator charging, &c. The Crypto Company have also published a price list of their A.C. single, two, and three-phase motors. This firm makes a distinct speciality of small machines of sizes up to 15b.h.p.

Punching and Shearing Machines.—HENRY PELS & CO., LONDON, W.C.—A well-got-up catalogue, illustrating the many well-known machines of which this firm makes a distinct speciality. The majority of the machines shown are arranged for the electric drive.

Bells.—SUN ELECTRICAL COMPANY, LTD., LONDON, W.C.—Catalogue No. 157, Section B, is a very complete, well-bound book, listing a great variety of electric bells, buzzers and indicators, also relays and accessories in the shape of pushes, wood blocks, name plates, etc. In this list are also included descriptions and prices of accumulators, primary batteries, battery voltmeters, hydrometers, wiremen's tools, etc.

Electric Signs.—SUN ELECTRICAL COMPANY, LTD., LONDON, W.C. This company has established a reputation for the ingenuity and effectiveness of its various styles of electric signs and advertisements. The tradesman will find very much to interest him in this publication, which is Section "O" of Catalogue No. 159.

Telephones.—SUN ELECTRICAL COMPANY, LTD., LONDON, W.C. Section T, Catalogue No. 158 is a well-bound book of over 150 pages giving prices and particulars of every type of telephone and accessory.

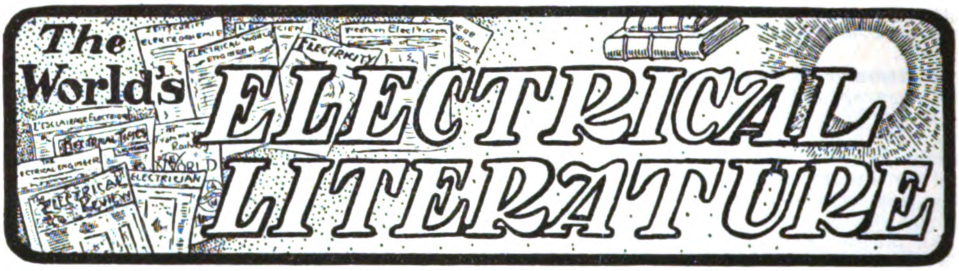
Transformers.—JOHNSON & PHILLIPS, LTD., CHARLTON, S.O., KENT. Printed in two colours and exceptionally well got-up, the catalogue of Messrs. Johnson & Phillips' "Air or Oil-Cooled Transformers" will be found of great interest. The construction and arrangement of the transformers are dealt with, and some particulars are given of their performance. Tables give the leading dimensions of the various sizes as suitable for single-phase and three-phase circuits. Messrs. Johnson & Phillips particularly advise that they will be glad to send copies of this book to anyone interested.

Pocket Calculator.—SCIENTIFIC PUBLISHING COMPANY, MANCHESTER.—This Company is advertising, by means of a circular, the well-known "Mechanical Engineer" Pocket Calculator. The watch type of slide rule is known to every engineer, but attention is drawn to the improvements which have been effected in this instrument, which was formerly supplied with a dial of 1¾in. diameter. This size has been increased to 2in., and the working parts have been re-designed and the instrument improved generally. The price, however, remains the same, namely 7s. 9d. each.

The publishers of "Sell's Telegraphic Addresses," which was accorded notice in THE ELECTRICAL MAGAZINE of last month, advise us that it is extremely important that the public should note that this edition cancels all previous issues, even the supplements to the 1907 volume published in September last. It seems that the Post Office has recently reminded the publishers of the fact that owing to the considerable trouble and delay that is caused, it is extremely dangerous to copy registered telegraphic addresses from other than the current volume and supplements of this directory.

APPOINTMENT WANTED.

BELGIAN MINING and ELECTRICAL ENGINEER, with good knowledge of English and German, proposes his services as Projecting Engineer of an Electrical firm or for Superintending an Electrical Plant. Moderate terms. Full particulars on application. Address, P.C.R., 49, Poste Restante, Verviers, Belgium.



You should carefully study this page, as it will save you much valuable time. It is the key to the World's Monthly Electric Progress. We can supply the publications mentioned, or any article indexed, for a small fee. In writing us, enclose stamped P.C. for reply.

Power.

Calculations for Power Plants. F. H. Hirschland.	*Electrochem. and Met. Ind., Feb./08.*
A Survey of Electric Power Transmission in Mexico. W. D. Hornaday.	*Westn. Electn.,* 1/2/08.
Hydro-Electric Development on the Chicago Drainage Canal.	*Elec. Rev., N.Y.,* 8/2/08.
Induction Motor Starters. D. E. Carpenter.	*Elec. Rev., N.Y.* 8/2/08.
Motor Generators: Their Use and Operation. N. G. Meade.	*Power,* 11/2/08.
Steel-Tower Transmission Line Construction in Sweden.	*Elec. Engng.,* 20/2/08.
A New High-Tension Pole Switch.	*Westn. Electn.,* 8/2/08

Traction and Transport.

Electric Railways in Switzerland. S. Herzog.	*Elek. u. Masch.,* 12/1/08.
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The Shelling-out of Steel Wheels and Tyres. G. L. Fowler.	*Rly. Gaz.,* 14/2/08.
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(51st Issue.)

The Electrical Magazine.

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The World's Electric Progress.

Electricity in Iron and Steel Works.

THIS number of THE ELECTRICAL MAGAZINE, which forms the third of our industrial series, has been produced with the dual object of bringing the needs of the iron and steel works engineer prominently before electrical plant manufacturers, and also of acquainting those having control of the iron and steel industries with facts concerning the ways and means of applying electricity to suit their needs. We feel particularly gratified with the way in which engineers of iron and steel works and electrical men have welcomed and aided our efforts, and our sincere thanks are due to those who have extended to us their support.

Contracts for the electrical equipment of furnace plants and steel works mean very big orders, and, most important of all, orders that represent good business in that plant and prices are not "cut." The electrical work necessary for iron and steel works service requires to be of the very best, and the iron-works engineer knows sufficient to prompt him to get the best irrespective of price. We commend this field of work to electrical plant manufacturers.

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The Mining Exhibition, Olympia.

JUST as coal-mining is the most important home industry of this country, so in our great Colonies, such as South Africa and Australia, mining perhaps claims the bulk of invested capital. It is, therefore, only fitting that Mr. H. Greville Montgomery, M.P., who has organized all the colliery exhibitions held in London, should also be the organizer of the World's Great Mining Exhibition, which is to be held at Olympia from July 11th to 31st next, and is a natural extension of the former.

The first colliery exhibition, held at the Agricultural Hall in 1903, was followed by two more in 1904 and 1906 respectively, and the progressive expansion shown was so great, and there were so many of the firms interested who made machinery for gold, diamond, copper, and tin mines as well as for collieries, that it was decided to widen the scope of the Exhibition and embrace mining of every kind and description. For this purpose it was necessary to have more extensive accommodation than that afforded at the Agricultural Hall, and the forthcoming Mining Exhibition will therefore be held at Olympia, where in April last Mr. Montgomery made such a great success of his seventh biennial Building Trades Exhibition, to which T.R.H. the Prince and Princess of Wales paid a special visit.

That the extension of the Mining Exhibition has been appreciated is evident from the bookings up to date, which not only show the support, as might be expected, of many new mining machinery firms, but also a marked increase in the size of the spaces taken by the old clientèle of the colliery exhibitions. Moreover, the Governments of

Natal and the Transvaal and Orange River Colonies, the Australian Colonies, and Canada, have promised their official support, whilst invitations have been sent to all the leading mining associations in the world to send delegates. With this concentration of interests, an exceptionally comprehensive and representative exhibition should be assured, the more especially since another such is not contemplated for at least four years.

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The Electrical Exhibition, Manchester.

GREAT progress is being made in the organizing of the Electrical Exhibition which is to be held in Manchester during October of this year. A preliminary prospectus has been circulated, and from this it is gathered that a great success is practically assured. The following abstracts from the published circular speak for themselves and indicate the thorough way in which the organizing committee are undertaking the work. There is great room for a good electrical exhibition just now to give a fillip to the trade, and it is to be hoped that all manufacturers will realize the benefits which are sure to accrue from this enterprise and that they will extend it their full support. The exhibition is directly under the patronage of the Institution of Electrical Engineers, the Municipal Electrical Association, the Manchester Chamber of Commerce, and the National Electrical Manufacturers' Association, Incorporated; in addition to which, direct and influential support has been accorded to the movement by the following Corporations—Manchester, Salford, Bolton, Buxton, Barrow, Bury, Bradford, Batley, Barnsley, Derby, Dewsbury, Eccles, Elland, Hull, Heywood, Nottingham, Rochdale, Ratcliffe, Stretford, Stockport, and Warrington. The exhibition will be run with a view solely of commercial and financial success, and not for private gain. The profits arising from the exhibition will be distributed by the Executive Committee as follows: In a percentage return to exhibitors; in a percentage return to contributors and donors; and contributions to charities connected with the electrical industry—the surplus, if any, to be specially dealt with by the Committee as they think fit.

To instance the high value which is attached to this exhibition, it may be mentioned that the Corporation of Manchester have offered a site in the important district of Fallowfield, the centre of the residential district, free of rent, and that various Corporations, both in Lancashire and Yorkshire, are making donations towards the funds of the exhibition, and such Corporations have further evinced the great interest which they have in the exhibition, by expressing their desire of furthering the scheme to any extent within their power. In view of the indications of support which have already been received from many important electrical manufacturing companies or firms, it has been decided to erect a special building covering a space of over one hundred thousand square feet, suitable for the purposes of the exhibition.

Arrangements have been made with the Electricity Committee of Manchester for a full supply of necessary electric energy; direct current at 200 volts for lighting and 400 volts for power, alternating current three phase 400 volts. Motors above 3½h.p. can only be supplied at 400 volts pressure. The management will deliver current to exhibitors' stands at a charge of 2d. per unit for lighting, and 1d. per unit for power, the rent for meter and necessary fuses being from 21s. to two guineas according to the size demanded.

Having regard to the fact that the exhibition is to be held in Manchester, it is proposed to invite manufacturers of textile and mining machinery to be represented, and to arrange for various exhibitors to have working exhibits of such machinery, so that owners of works, mills, factories and mines (of which there are a vast number in the North) will be able to see for themselves exactly how electricity can be applied to the business in which they are interested.

ELECTRICITY IN IRON AND STEEL WORKS.

THE ELECTRICAL POINT OF VIEW.

WHILST electricity has to-day become the universal power agent in every trade and manufacturing process, its connection with the great iron and steel making industries is, for many reasons, a peculiarly close one. There has already been quite a large amount of labour spent and good results gained in the uniting of the ironmasters' and electrical engineers' workaday interests; yet it would seem that only the surface of this combination has been touched; the more one looks into the many directions opened out by this preliminary or pioneer enterprise in the development of the electrified iron and steel works, so does it become the more clear that in this sphere lies one of the most certain and promising markets for the electrical manufacturer.

Heavy powers, great heat—these are the very essentials of iron and steel manufacture. Electricity can provide both, and does so to the best advantage when the demand is, as in this case, for a very large and constant supply. Again, there is the all-important factor that the generation of electricity is the natural means of conserving the great amount of energy existent in otherwise useless products of manufacturing process, which hitherto has been neglected as being in an inaccessible form from the commercial point of view. Whilst the success of realizing this valuable asset rests with the designers of the large gas and steam units, particularly the former, their efforts have become of the greatest practical worth when applied in conjunction with modern electrical plant. Iron and steel works are rough and ready places, mostly open and exposed, the plant is spread over a considerable area, and the machinery receives, as a rule, scant respect from the operator, and is subject to every deleterious condition of surroundings and position. The merits of the electric motor, and the electric system generally, for service under such adverse circumstances are proverbial.

As to the claims of electricity as a useful heating agent in iron and steel production, it is to be noted that electric furnaces for this work have for many years been the study of leading engineers of this country and abroad, and that several types and forms have been put into commercial operation. These have been at work so long now that practice can be said to have settled the doubts as to their feasibility; the results obtained prove that the electric furnace has come to stay, and its use must be reckoned as one of the most important methods entering into modern iron and steel production.

In reviewing the general applications of electricity in iron and steel works it will be well to subdivide the subject into Power Generation, Power Application, and Electric

Furnaces, leaving out of the question, in this case, matters of electric lighting, and the smaller applications, such as bells, telephones, &c. There is also the further necessity of dealing separately with iron works practice and steel works practice; there are many firms in this country who undertake only one or the other of these trades, although there are also some who combine the two. It will be seen that the latter practice is likely to become more common in view of the undoubted economies which are to be effected with modern methods when iron and steel are made side by side in one works.

Electric Power Generation.

In this country is to be found every type of steam-electric and gas-electric power station in use for iron and steel works requirements; abroad there are in addition many examples of hydro-electric installations put down expressly for the same purpose. In every case the main considerations are economy per horse-power hour and reliability. The use of high-pressure steam-driven plant supplied from coal-fired boilers, the usual way of generating current for any purpose in this country, does not introduce any special feature for mention here—except that in view of other methods in use it is expensive. Quite a common method of power generation is the next stage better, which retains the high-pressure steam sets, but supplies them from boilers fired with furnace or oven gas. The latest and most economical method goes a stage further and utilizes the furnace or oven gas direct in the cylinders of internal combustion engines, there being no intermediate conversion of the energy by means of steam. The relative economies of the several methods have long been known, and it has merely been a matter of solving problems bearing upon first cost and maintenance of plant that has delayed the general advance of large-sized gas engines. The fact that gas engines are now being put down frequently in sizes up to 4000b.h.p. each for operating with blast furnace and producer or coke oven gas proves that the revolution of generating cheap power in bulk direct from gas supplies has set in, and it is this method of power generation which has obviously the greatest claims upon the iron and steel works engineer's attention. There has been a great deal of labour and ingenuity expended upon the ways and means of rendering the waste gases, of furnaces in particular, of suitable form and quality for regular successful use in engines, and undoubtedly much of the trouble experienced with the earlier furnace-gas power plants was due to inefficient cleansing of the gas, and its greatly varying composition as yielded by the furnaces. But it would seem that the greatest impediment has rested in the design of the engines themselves; the operating cycle, the design of valves and ports, the general proportioning of engine parts, all combined to bring forward troubles in practice impossible to foresee. As a result there are many engineers to-day who cherish an antagonism towards the large gas engine based upon bitter experience. But times have moved rapidly in this branch of engineering: what was considered less than ten years ago a generally hopeless failure—the large gas engine—is every day more and more asserting its triumph as a practicable and commercially sound investment.

There is another type of engine or prime-mover of recent introduction which merits particular attention especially where—and this is usually the case—the question of modernizing existing works is to be faced. The exhaust-steam turbine is being largely taken up for the purpose of reclaiming the waste energy of the atmospheric exhaust of high-pressure engines. This system is peculiarly suitable for rolling mills' plant, for the reason that owing to the very high power of the mill-driving engines, combined with the extreme variation of such loads, exhaust economies in the usual way by condenser are impracticable. The turbines are of the usual type as for boiler pressure working, excepting that they have the necessary proportions for working at the reduced range of pressure from atmospheric to as near theoretical zero as possible. In combination with the turbine and condenser equipment is, for the rolling mills system, a thermal storage or exhaust reservoir for the purpose of equalizing or maintaining an even supply of the main engine exhaust steam supply to the turbine. Full particulars of this method of electric power generation are given in another part of this number. As evidence of its importance it may be mentioned that in some cases independent installations are put down in which the exhaust steam is purchased, and the purchaser utilizes this for the purpose of providing a public electric supply in the neighbourhood.

In discussing the electrical side of the power-generating question, one is at the outset led to a consideration of the respective merits of the direct-current and alternate-current systems. There are many examples amongst iron and steel works of each kind of equipment, and some few of the largest works have both types of circuit in use. So far as the generating plant is concerned, the choice is practically a matter of indifference; in either case the size of units required in a fully electrified works is so large that only the close and proper following of public central station practice — now practically standardized—is permissible. The electric generating plant of a modern iron and steel works is indeed equipped, arranged and operated as is usual with public supply stations where low generating costs and the maintaining of a continuous supply are the foremost considerations. There are, however, many works in this country which purchase their current supply from an outside source; whilst the advisability of this naturally depends upon local conditions such as price of current, nature of supply, existing works power plant, &c., it would seem that the purchase of current in a suitable form and at even the most reasonable rate per unit is not necessarily to be recommended. Other writers in this number have discussed the point, and it would seem, generally speaking, that the electrical power requirements of an iron and steel works arranged for electrical driving throughout are so large and constant, and the facilities for cheap power generation are such as to make the putting down of a private generating station a sound commercial investment.

Power Application.

It is when dealing with the actual uses of the motors for the hundred and one services in the works that the respective merits of the direct-current and alternating-current systems are most in evidence. The extreme simplicity of the alternating-current motor is at once its strong recommendation for service under the arduous conditions of exposure, heat, dirt, and rough handling which prevail in iron and steel works. Further than this, it is particularly adaptable to ease of control and to great reliability in service even in the largest sizes. The pressure of the alternate-current supply can be conveniently and efficiently raised or lowered as desired by means of static transformers, and high-tension currents, with their superior economies and convenience of transmission, can be supplied direct to the motors without introducing any greater risks of failure or breakdown than occur with low-tension alternate-current machines, and with less risks than are usual with direct-current motors operating under similar rough conditions. For the driving of rolling mills, certainly the heaviest, most variable, and in every way the hardest service to which the electric motor could be applied, the alternate-current motor has proved to be entirely successful, and there are many such installations in constant use here and abroad. Even for variable-speed working the alternate-current motor has been brought into line, and for most purposes can to-day replace the direct-current motor in those drives wherein, speed regulation being necessary, the direct-current machine was deemed essential.

As compared with the alternate-current motor the particular disadvantage of the direct-current machine is its susceptibility to dirt and damp; the wound armature, the commutator and brush gear, must in any case be enclosed in so-called dust and water-tight cases, the best of such cases leak to some extent, resulting in sparking, electrical leakage, and excessive wear-and-tear on the commutator. There is also the serious disadvantage that the totally enclosed motor, denied of ventilation, is subject to high internal rises of temperature, the effect of which is lessened or avoided only by increasing the size and cost of the motor for a rated output. In addition to these there are the further disadvantages of cumbersome and expensive starting and controlling apparatus for the larger sizes of direct-current motors, and the fact that heavy overloads on the machine as a rule result in its damage and breakdown.

Considering this comparison, one might wonder how the direct-current motor came to be used so widely in iron and steel works. The fact is that it was first in the field, and its general use for a wide variety of industrial purposes, long before the alternate-current motor became a practical success, gave engineers a full knowledge of its capabilities and principles of operation under certain classes of loads. For example, with intermittent and widely varying loads such as are general in the driving of rolling mills or punches and shears, it has, of course, long been understood that flywheel momentum provided the only practical mechanical arrangement, and it was simple to see that when the demand of heavy load made a call on the flywheel power reserve the driving motor should slacken its speed to allow of the flywheel supplying the sudden demand. The direct-current motor automatically falls in speed as its load increases, and consequently suited such drives. On the other hand the alternate-current motor has until lately been looked upon as a constant-speed machine—as, indeed, it practically is, the variation in speed of the standard alternate-current motor between light and full load running being only very slight. The result of this was that in many of the earlier applications of the alternate-current motor to iron and steel works plant, trouble was often met in the form of mechanical breakdowns, shafts would break, keyways and pinions strip, and so on; all of which tended to advance and confirm the use of direct-current machines. But since those early days of alternate-current power practice very great developments in the motors have taken place both in their electrical and mechanical design. Their operating principles are now clearly understood, and alternate-current power can be applied with success to any power service.

It is perhaps hardly necessary to mention that motors and their accessories of starters, controllers and switches must of necessity be of the strongest and most liberal designs when intended for iron and steel works usage; it is in want of attention to this point that many electrical manufacturers have proved short.

The power equipment as suited to the average factory or tradesman's shop is absolutely no use for steel works or blast furnace service; even the heaviest grades of plant as made by some of our leading manufacturers have proved insufficient, and it is a fact that there are iron and steel firms who have actually started to build electrical machinery for themselves. This is not pleasant to think on, nor does it follow that the practice of combining electrical plant manufacture with the making of pig-iron or the rolling of steel plates will become common, but it is worthy of remark in passing and will add weight to the suggestion that there is in the iron and steel trades a demand for a line of motors and switchgear more massive and strongly designed than are the usual standard products of the electrical manufacturer. It is quite true that competition in the electrical trade is of the keenest, and that the makers must cut down materials and labour to a minimum to complete orders with only a mere margin of profit—at least that is so with orders placed solely on price, and doubtless there are very many of such. But it is a fact that for iron and steel works service the customer requires first and foremost the right machine, and in securing that the question of price becomes a secondary consideration; so long as he can be assured of the electrical plant standing up well to its work, he will have that plant and will pay reasonably for it. There is a large and profitable market in the iron and steel works of this country open to the enterprising electrical manufacturer who will lay himself out to supply power plant properly suited for the arduous services.

Electric Furnaces.

The use of electricity for the extraction of iron from its ores and for the refining of the products is undoubtedly one of the most interesting subjects before the engineering world to-day.

It is in this that the efficiency of electricity as a powerful heating agent is demonstrated. The enormous temperature of the electric arc is in some of the furnaces commercially applied to the remelting of scrap to produce high-carbon steels, and a similar type of furnace has been used experimentally for the production of steel or iron direct from the ore. It is, however, in the making of specially pure iron and high-grade steels that the electric furnace is most often used on the commercial scale; and in these cases the furnace is of the "induction" type.

The furnace charge occupies an annular space and forms the low resistance closed secondary of a transformer. It will be seen how extremely simple the electrical arrangements of an induction furnace may be; the high-tension primary of the furnace can be built in solid, and there is no need to have exposed electrical contacts of any description in the neighbourhood of the furnace. The great advantage of the induction furnace rests in the fact that the heating agent does not introduce any fuel, electrode, or foreign body into contact with the molten charge; consequently an absolute uniformity and purity of product can be obtained.

Elsewhere in this number are published descriptions and statistics relating to work already done in this direction, and it will be noticed that certain of the processes have acquired distinct commercial value. It would seem that only the very beginning has been made with this important branch of engineering. In this country, on the Continent, and in America experiments on a large and comprehensive scale are being made regularly, and there is every reason to believe that this development holds out for the electrical and for the iron and steel industries the very greatest possibilities in the near future.

* * *

THE DEVELOPMENT OF ELECTRIC POWER IN IRON AND STEEL WORKS.

H. H. B. DEANE.

During the last few years the application of electric power has made great strides in all departments of iron and steel works. The first step was made in the direction of transporting arrangements in the shape of overhead travelling cranes and transporter rolls, where the superiority of control, transmission, and adaptability very quickly ousted all other systems. This became so evident that in laying out a new mill and attendant plant any up-to-date engineer and manager makes provision for obtaining electric power one of his first considerations, and from this point on finds his path made easy.

After electrifying the transporting gear, the progress of electrical power was steadily maintained throughout the whole series of auxiliary machinery, such as the hot saws, hot and cold shears, both bar and plate cutting machines, live roller gear and roll-lifting and screw-down gear, plate straightening and bending rolls. This application of electric driving to machines which were previously steam or hydraulically driven gave the engineer concerned much food for thought, as will be seen from the illustrations, which show typical examples of the conversion of old plant to the new driving power. In the case of new auxiliary machinery the arrangement of electric driving is of course very materially simplified.

Arrived at this stage of progress, it seemed as if further advance was impossible. This check, however, proved to be only temporary, and has been overcome by the great development of continuously running prime movers along two entirely independent lines, viz., the introduction of the steam turbine, and the improvement of the internal combustion engine for large units. Both of these developments have been to a very large extent due to electrical requirements. This dual advance has again thrown open the field for electrical driving in two ways—first, by reducing power generation costs, both from the capital and running cost points of view; and what is more important still, the possibility of obtaining the whole power required from what were previously considered unimportant by-products, thereby making the electric driving of the rolling mills themselves commercially possible.

The engineer has to decide on the system which is to be adopted for generation. If blast furnaces are attached to the plant, the question at once arises as to how much spare gas he has to devote to power generation. The spare gas available, after that which is required by the blast-furnace auxiliaries has been deducted, may safely be taken as being equivalent in horse-power to the number of tons of iron made per month when gas engines for power generation and blowing the furnaces are used. If, however, the power is obtained by steam-driven generating plant and blowing engines, the

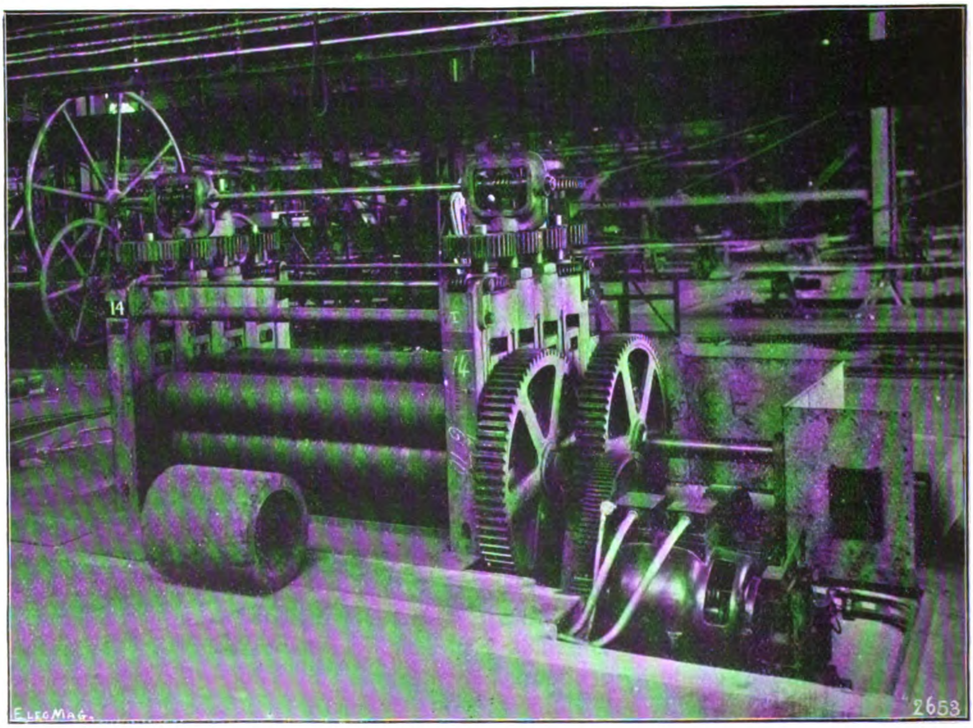


Fig. 1. Plate Straightening Rolls Driven by General Electric Company's Motor.

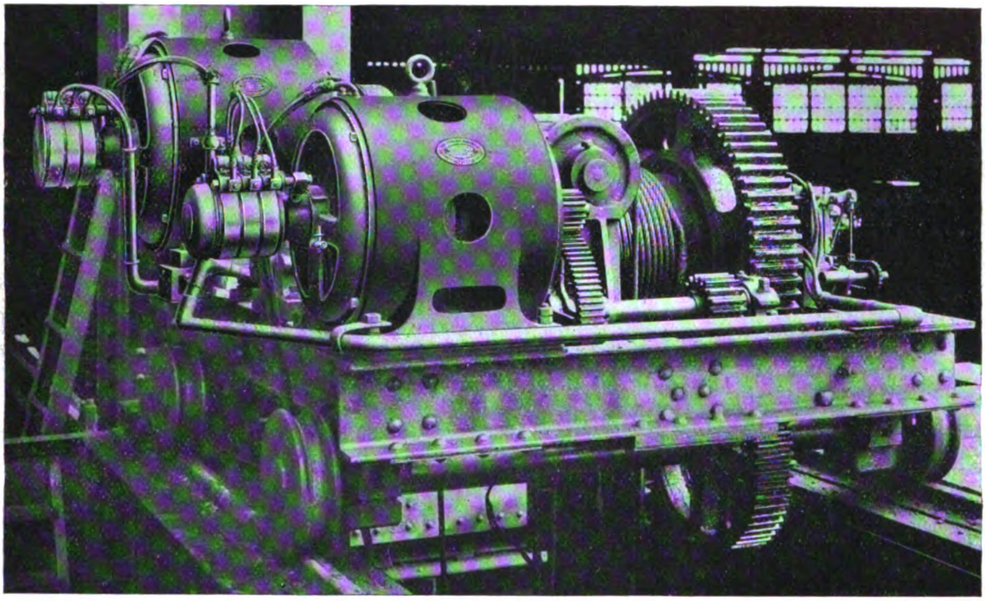


Fig. 2. Crab of Travelling Crane fitted with General Electric Company's Three-phase Motors.

same quantity of gas would not produce more than a fourth of this power. This factor will have a predominant influence in the settling of this question, depending, of course, on the ratio of steel finished to pig iron made.

Now, taking a plant having an output of 120,000 tons of steel per annum finished to plates, bars, and girders with electrically driven cogging and finishing mills, also auxiliaries, and equipped with furnaces for turning out the equivalent amount of pig, the electric station would have to be capable of supplying 3000kw., which would best be made of three 1500kw. units, giving one spare unit. The output of 3000kw. as taken is made up as follows: 1600kw. to supply the two main mill motor generators, and 1400kw. for all auxiliaries. This power could be just supplied by the furnaces—*i.e.*, if pig iron is only made for internal consumption—if steam generating plants were adopted.

With gas-driven generating sets the capital outlay would not exceed £12 per kw. installed, inclusive of gas engines, direct-coupled generators, either continous current or alternating three phase, together with switchboard apparatus, gas cleaning plant, foundations and buildings.

On the other hand, if steam turbines are employed, the capital outlay will hardly be less than £14 per kw. installed, inclusive of steam turbo generators with surface condensers as before, switchboards and connections, boilers of water-tube type, economisers, steam, exhaust, and boiler-feed pipes, foundations and buildings, inclusive of flue and chimney work. Therefore, on capital account alone the generating costs will be considerably higher. Further to this must be added the supply of boiler feed, make-up water, which alone, even with the surface condensers, will equal the amount required for cooling and gas cleaning, and to this must be added the amount of water required for the condenser supply, which will closely approximate 140,000 gallons per hour; this may be dealt with, of course, by means of cooling towers, but in this case the capital account per kw. will have to be increased as no allowance has been made for such treatment.

The cost of gas-driven blowing engines and equipment would probably be slightly higher in capital cost than if turbo blowers were used; the difference, in the writer's opinion, would probably be very small indeed, and would by no means counterbalance the difference in outlay for the electrical plant, This point, however, he has not had an oppor-

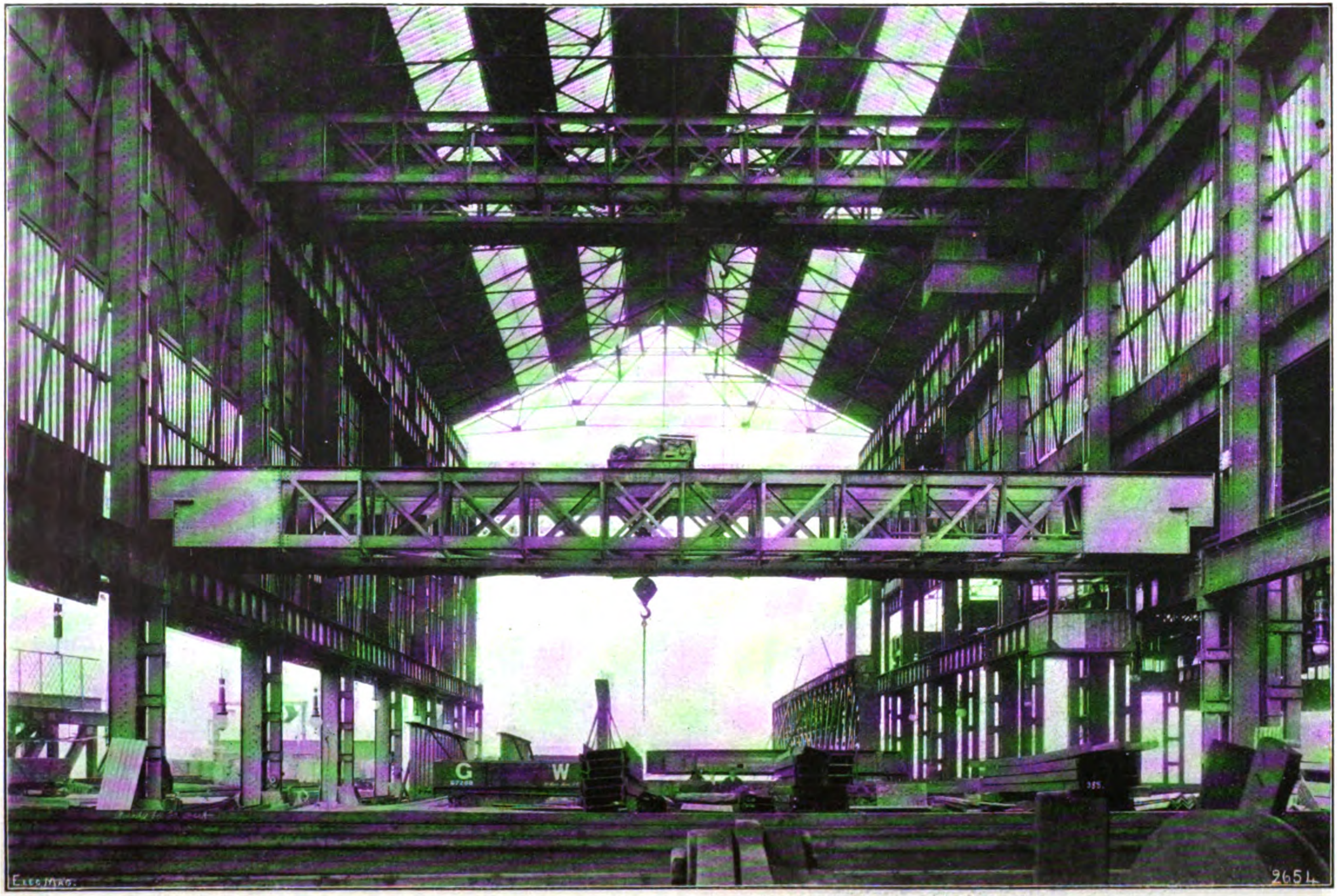


FIG. 3. ARRANGEMENT OF DOUBLE-TIER OVERHEAD TRAVELLING CRANES ON LOADING AND FINISHING BANK. ELECTRIC EQUIPMENT BY THE GENERAL ELECTRIC COMPANY.

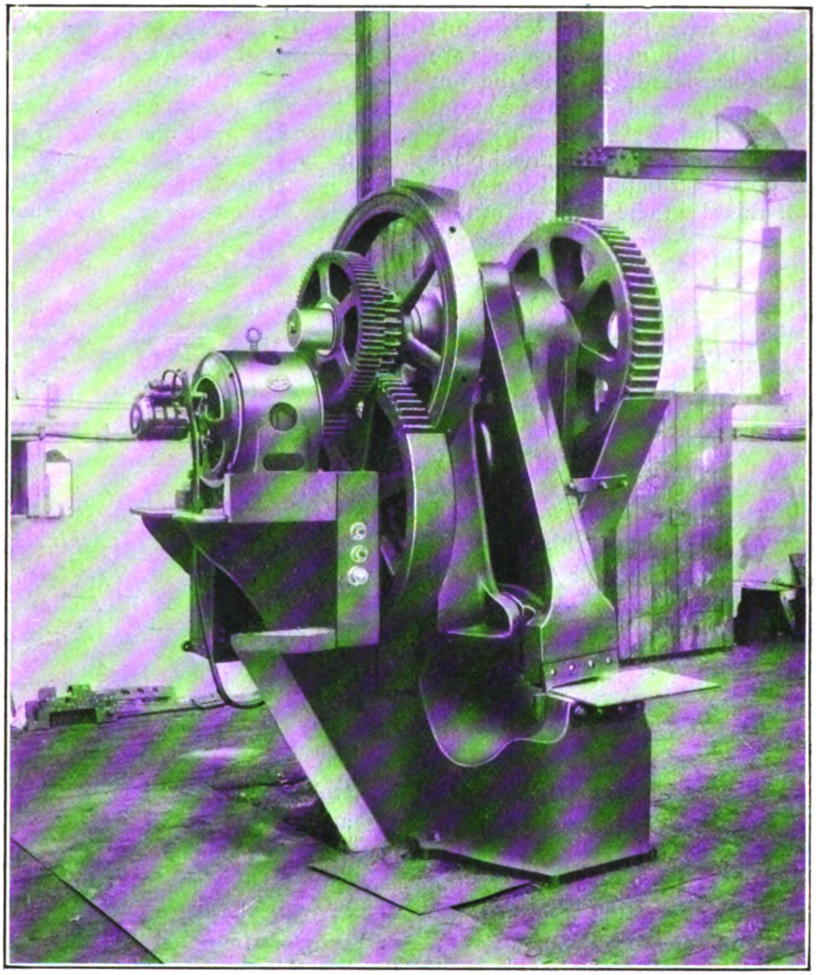


FIG. 4. PLATE SHEARS SHOWING THE CONVERSION FROM STEAM TO ELECTRIC DRIVE.

tunity of comparing, having been more concerned with the electrical side of the problem; on the other hand, if turbo blowers were resorted to, the overall thermal efficiency, being lower, would in the case given necessitate the gas firing of the boilers being augmented by a small fuel allowance, which would again increase the running costs.

As tending to controvert the objection which is usually raised against the adoption of internal combustion engines—*i.e.*, reliability and maintenance cost—it can be pointed out that there are gas engines in this country even which have run continuously for six months at a stretch, and then were only stopped for inspection, because it was thought advisable to do so in order to ascertain what wear and, if any, accumulation of matter had taken place in cylinders, valves, and seats. It was only deemed necessary to grind the valves into their seats, after which the engine was closed up and set off for another six months, about five months of which have now elapsed without the necessity occurring for shutting down. This result has been obtained by giving very careful attention to the cleaning of the gas, which point till recently had not had sufficient attention paid to it, and which has been at the root of nearly all the troubles which have occurred up till now.

Finally, it may be pointed out that all those firms who have had any reasonable experience with blast-furnace-gas engines are extending their use steadily, till in the not far distant future they will not have a steam engine on the ground.

With regard to the purely electrical plant —*i.e.*, generators, distribution, and motors— for plants of this size there is no doubt that three-phase alternate current is the best system to adopt, owing to the simplicity of collection and the possibility of using a higher potential, thus reducing the troubles raised when heavy currents have to be handled which, in large units, far more than counterbalance the extra insulation which may be required for the higher pressure but cheaper alternate current system.

* * *

THE ELECTRIC FURNACE AND ITS PRACTICAL APPLICATION.

E. ADAMSON.

(The Author of this article is Manager of the Special Iron Department of an important British Iron-works. He has had considerable experience in this country and on the Continent in the production and use of special iron for all purposes, and has engaged in much research work. The results of some of his original experiments as published recently before the Iron and Steel Institute showed tests giving the highest recorded values for Cast Iron.—ED. E. M.)

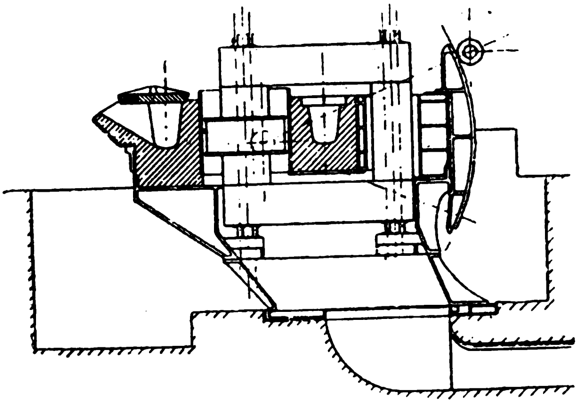
* * *

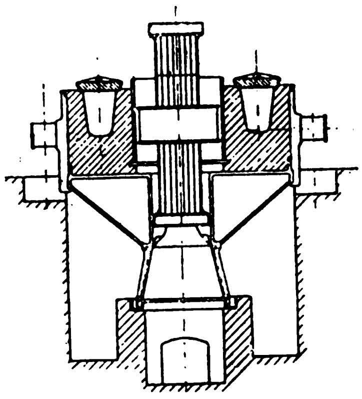
ELECTRIC furnaces were used experimentally in the production of various metals long before their use in the manufacture of iron and steel. Among the earliest patents in connection with their use for steel is that of the old veteran metallurgist, the late Sir William Siemens, who took out Patent 2110 in 1879 for an electric furnace. This furnace was in the form of a crucible, with an electrode fitted in the bottom and a water-cooled metal electrode lowered into the crucible from the top by means of an automatic regulating device. After many experiments Sir William Siemens, in estimating the cost of melting, came to the conclusion that the gas melting furnace and the electric furnace, which were equal in efficiency, each required the equivalent of one ton of coal or coke to melt a ton of iron. In other words, the ton of gas producer coal in normal times would cost about ten shillings, and coke would cost about sixteen shillings per ton. In the light of modern steel-making, however, working the pig and scrap process, otherwise all cold materials, for comparative purposes, it may safely be taken that a maximum limit of 10cwt. of coal will produce a ton of steel, or say a maximum of five shillings per ton for fuel only.

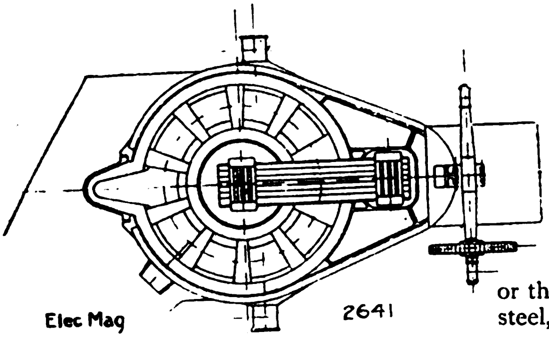
No great progress seems to have been reported during the next twenty years in connection with the use of the electric furnace in the manufacture of steel, although many experiments were being conducted in France, Germany, Sweden, and America. Both Héroult and Kellier took out patents in 1900 for their furnaces and processes, and the electric furnaces now in use in different parts of the world can be divided into three types :

1. Induction furnaces (Kjellin type) ;
2. Resistance furnaces (Héroult and Kellier) ;
3. Arc furnaces ;

and all three, or modifications of these types,







ELECTRIC INDUCTION TILTING FURNACE.

are more or less now being used in one or other direction in the manufacture of iron and steel and alloys of the rarer metals, such as tungsten, chromium, titanium, molybdenum, vanadium, &c.

The Induction Furnace.

This type of furnace is a large crucible in which iron and steel are melted by means of an "induced" current, and the materials to be melted are not in contact with the electrodes, which are protected from the metal and furnace gases and are therefore practically free from oxidation. The principal furnace of this type is the Kjellin, which has been operated at Gysinge, Sweden, since 1900.

It is generally admitted that this particular furnace is more suitable for melting than for smelting, and therefore its greatest competitor is the crucible furnace, which it most nearly approaches for melting steel. One very great advantage of the electric furnace over the crucible is that whilst steel melted in the latter may pick up sulphur to the extent of 0.02 per cent. and upwards from the coke, owing to the porous nature of the clay crucible, steel melted electrically does not pick up sulphur, the metal not being in any way in contact with material which gives off sulphur. One thing, however, appears certain, that whether the crucible or the induction furnace is used for melting steel, in order to obtain a pure analysis the same exceptionally pure materials must be employed, there being no elimination of impurities in either method of melting; hence in its present form the induction furnace appears to be useful only in the manufacture of high-class tool steels and the like—the alloys for "killing" have also to be used in both cases.

In order to arrive at a comparison of costs of melting it is necessary to consider the actual cost of the electric current per ton of product and its equivalent cost in this country. The figures of costs at present available work out as follows :—

	(*a*)	(*b*)
Steel with carbon, per cent.	1.10	.40
E.H.P. years of current per ton of ingots	.13	.16
Cost of current per ton of steel ..	5s. 2d.	6s. 5d.

The cost of the e.h.p. year in this case is taken at 40s., which is equal to 0.075d. per unit. To produce electricity at this figure requires water power, whilst in this country, under the most favourable conditions, it is not safe to calculate upon less than 0.35d. per unit as the cost of electric energy. In an ordinary way the cost of making the current can be taken at about 0.45d. per unit if generated on a fairly large scale; and if the current has to be bought, the lowest price, for a very high load factor, would probably be about 0.50d., but would be more likely to be 0.60d. to 0.75d. per unit for the average works' requirements. These costs of current work out per ton of steel melted as follows:—

	Per unit.	(a) C 1.10%	(b)C. 0.40%
		Per ton.	Per ton.
Lowest estimated cost	0.35d.	£1 4 1	£1 9 11
Average cost of producing	0.45d.	1 11 1	1 18 6
Lowest purchase price	0.50d.	1 14 7	2 2 11
Probable purchase prices	0.60d.	2 1 6	2 11 6
	0.75d.	2 11 10	3 4 4

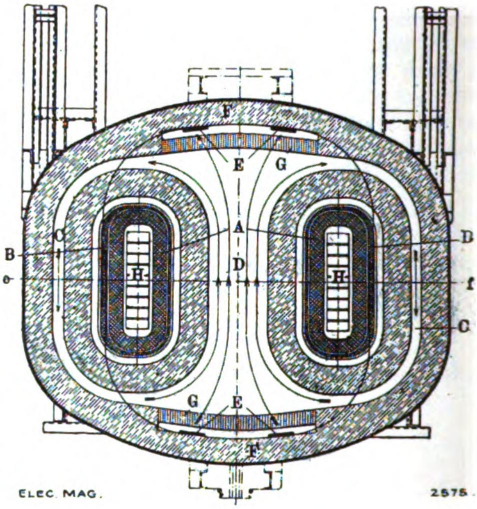
The purer the steel the higher will be the temperature required, and hence the greater will be the current used.

The above figures are based upon ordinary tool steel mixtures charged cold.

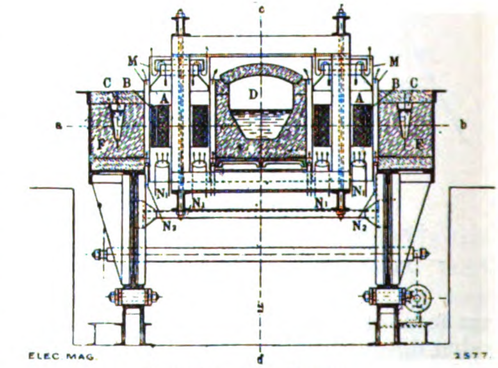
Resistance Furnaces.

The heat generated in this type of furnace is by means of the electric resistance offered by the furnace charge to the electric current, hence the term "resistance." The chief furnaces of this type are the Héroult and Kellier furnaces, both of which are at the present time used in the manufacture of steel and ferro-alloys.

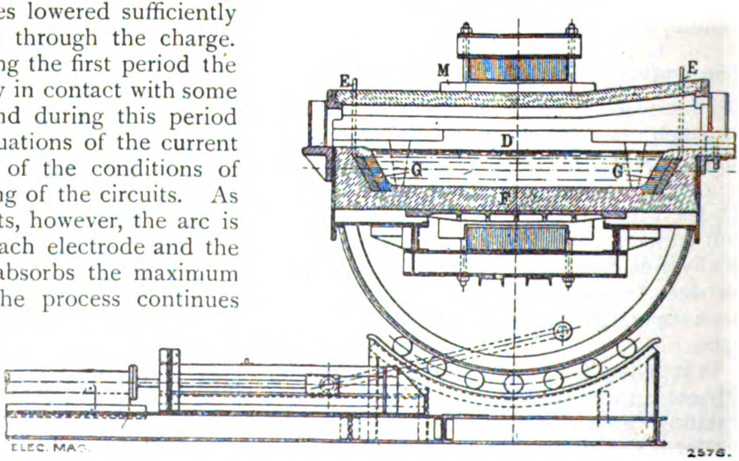
The Héroult furnace, which is a tilting one, has been in operation for several years in Sweden and also in France, and one advantage it has over the induction furnace is that a much greater heat can be developed. It may be as well to consider this furnace first as for melting only, as compared with the induction furnace. The materials would be charged in the ordinary way, and the electrodes lowered sufficiently to establish a current through the charge. In melting down during the first period the electrodes are generally in contact with some part of the charge, and during this period there are violent fluctuations of the current due to the changing of the conditions of contact and the moving of the circuits. As the entire charge melts, however, the arc is established between each electrode and the molten iron, it then absorbs the maximum energy, after which the process continues as in an ordinary Siemens furnace.



Plan in Section.



End Elevation Section.



Side Elevation Section.

The Roechling-Rodenhauser Furnace: Combined Induction and Resistance Type.

The costs of melting in the resistance furnace appear to be somewhat higher than those of the induction furnace, although this

	Capacity of Furnace.	10cwt.	1 ton.	2 tons.	3 tons.	4 tons.	5 tons.
1st slag	Kw. hours	1200	940	840	780	750	730
2nd slag	,,	1275	1040	930	870	840	790
3rd slag	,,	1450	1130	1020	940	920	870
		Per ton. s. d.	Per ton. s. d.	Per ton. s. d.	Per ton. s. d.	Per ton. s. d.	Per ton. s. d.
1st slag	Cost	7 6	5 10	5 0	4 10	4 8	4 6
2nd slag	Per unit	8 0	6 6	5 10	5 5	5 3	4 11
3rd slag	0.075d.	9 1	7 3	6 4	5 10	5 9	5 5
		Per ton.	Per ton.	Per ton.	Per ton.	Per ton.	Per ton.
1st slag	Cost	£2 5 0	£1 15 0	£1 10 0	£1 9 0	£1 8 0	£1 7 0
2nd slag	Per unit	2 8 0	1 19 0	1 15 0	1 12 6	1 11 6	1 9 6
3rd slag	0.45d.	2 14 6	2 3 6	1 18 0	1 15 0	1 14 4	1 12 6

may be accounted for by a difference in the size of the charges. The figures for resistance furnaces as given are as follows:

Current Cost per unit.	Cost per ton of Product.	
	C. 1.00 per cent.	C. 0.079 per cent.
0.075d.	£0 6 10	£0 6 10
0.35d.	1 11 10	1 11 10
0.45d.	2 0 11	2 0 11
0.50d.	2 5 5	2 5 5
0.60d.	2 14 6	2 14 6
0.75d.	3 8 2	3 8 2

To these charges must be added about 6s. per ton of steel produced on account of the cost for electrodes.

The particular advantage of the resistance furnace, however, is the possibility of its application in the refining process, thus permitting the working of cheaper materials to obtain the same purity of steel. This is accomplished by using a basic lining and changing the slags two or three times, making new ones by means of ore and lime, and if necessary continuing the changing of slags until the requisite purity is obtained, in the same way as slags are changed on a tilting regenerative furnace in structural steel manufacture.

The consumption of current for each operation in the melting and removal of slags, together with the cost of the current at the water-power rate of 40s. per e.h.p. year or 0.075d. per unit, and also what may be taken as a fair average cost of generating the current from coal, is given in the table at the top of this page, to which it will be necessary to add about 6s. per ton for the cost of electrodes.

Considered metallurgically, the Kellier melting furnace is of a somewhat similar type to the Héroult. The electrodes, of which there are four, pass through the roof of the furnace, and for purification the process is worked in a similar way to that already described by the successive removal of slags; the costs also, in an experimental furnace, have proved to be about the same as with the Héroult furnace.

The three furnaces just described are the chief ones in use in connection with the manufacture of steel, and the cost of the current seems to be the point upon which turns the possible introduction on a commercial scale of the electric furnace into more general use in this country, either for melting only or for refining, that is, for producing high-class steels from low-grade materials. At present it would appear that Siemens and Bessemer steel can be produced much cheaper than by using the electric furnace, even if the current is generated by water power, and this confines the use of the electric furnace to high-class work; hence it should, so far as practical work is concerned, be considered more as a melting furnace for special steels.

It may be interesting at this point to consider the cost of fuel for melting steel, say in the Sheffield district, in crucibles. The ordinary coke-fired crucible furnace usually requires about three tons of best hard coke to melt one ton of tool steel. The average cost of this class of coke is about 20s. per ton, hence the cost of fuel only may be taken at about £3 per ton of steel melted. In the gas-fired crucible furnaces the cost is very much lower. In the "New Form Siemens" crucible furnace, melting steel, the fuel consumption is about 22cwt. to 25cwt. of coal per ton of steel melted, which at an average cost, in normal times, of 10s. per ton, makes a maximum fuel cost of 12s. 6d. per ton of steel melted.

In the costs of current per ton of steel melted already quoted in connection with melting in the electric furnace, these are all in its favour, by reason of the size of the charges being greater than those of the crucible furnaces. To tabulate them, for comparison, they would be, for a tool steel of, say, C. 1.00 per cent.—

Per Unit.	0.35d.	0.45d.	0.60d.
Electric Induction Furnace, per ton	£1 4 1	£1 11 1	£2 1 6
Electric Resistance Furnace, per ton	£1 11 10	£2 0 11	£2 14 6
Coke Fired Crucible Furnace, per ton		£3 0 0	
Siemens New Form Gas Fired Crucible Furnace, per ton		12 6	

From these figures, even at a purchasing price of 0.60d. per unit, at which it should be possible to purchase the current for metallurgical purposes, the cost of melting in electric furnaces seems to compare very favourably with the coke-fired crucible furnaces, but when considered against the gas-fired furnace the advantage of the electric furnaces seems to break down.

In compiling these figures, the practical use of the electric furnace in this country has been kept in sight and considered from the point of view of those who are most interested in producing high-class steels, and the possible rates at which the current could be obtained by them, either by generating it for themselves or purchasing from an outside source.

Considered, however, from a wider point of view, these figures might be somewhat reduced, where production is on a very large scale. Mr. W. Murray Morrison has stated that under the most favourable conditions he did not believe that power from steam could be generated at less than from £7 to £8 per e.h.p.-year, but with the aid of gas the figure of from £5 to £6 might be reached—adding that the problem of the utilization of blast-furnace gases was particularly important and interesting in this connection. These figures would give a unit cost of 0.30d. and 0.225d. respectively, which for comparison would give:

	C. 1.10	C. 0.40
0.30d. per unit	£1 0 8	£1 5 8 per ton.
0.225d. per unit ..	15 6	19 3 per ton.

When such figures of cost of current are reached no doubt the electric furnace will come more into general use.

The Quality of Electric Steel.

It cannot be denied that the quality of electric steel is excellent, being undoubtedly much higher than that of Siemens or Bessemer. By the Froges-Héroult process the following analysis has been obtained from successive meltings:—

Sulphur %	Phosphorus %
0.011	0.003
0.012	0.003
0.007	0.002
0.018	0.002
0.014	0.003
0.013	0.006
0.008	0.004
0.017	0.003
0.008	0.003

The carbon, silicon, and manganese can of course be controlled as in other steel-making processes, but sulphur and phosphorus are very difficult to eliminate. Analytically, mechanically, and microscopically steel can be made in the induction and resistance furnaces equal to best crucible steel, and electric steel will also stand the workshop tests. Exhaustive chemical tests also show the electric steel to be very uniform in quality and free from liquation of the impurities. Mr. H. F. Donaldson, chief superintendent of the Royal Ordnance Factories, conducted a number of tests at Woolwich of electric steel against the best tool steels, and speaking generally there was found little difference between the steels tested, hence the field for the use of electric steel is by no means small.

Smelting.

Considered as a melting furnace there would appear to be some room for the adoption of the electric furnace, but comparatively little has been done in the direction of making pig iron, or of making steel direct from ore, and what figures are available clearly demonstrate that, for the present at any rate, the process is much too costly except where water power is available. Hence it is for the moment of little immediate *practical* interest to the metallurgical world, where fuel is required for generating electricity. The following, however, is a résumé of what has been accomplished up to the present time.

Of the resistance furnaces, the Kellier furnace and process is the chief of this type which has been tried for the purpose of producing pig iron or of making steel direct from ore. Kellier's first patents for the electrically heated iron smelting furnace are dated 1900. This furnace was not a large one, perhaps rather smaller than some of the early Swedish charcoal cold blast furnaces, but it somewhat resembled the modern blast furnace in the form of the upper portion—that is, bell shaped. The iron ore and coke with the fluxes are charged from the top in a manner similar to the charging of a blast furnace, whilst the electrodes were placed on either side of the furnace, and the materials were heated in their slow progress downwards by the currents passing between the electrodes. The ore is reduced to metallic iron in this descent, reaching the hearth of the furnace in a molten state, the slag passing off at a notch a little above the level of the tapping hole. The metal was then tapped off into the melting or refining furnace and steel produced therefrom in the usual way. The reactions of smelting are not unlike those of the blast furnace, and it was claimed that one ton of steel could be produced for 2800 electrical units, which works out :

at 0.075d. per unit = £0 17 6 per ton.
at 0.35d. per unit = 4 1 8 per ton.
at 0.45d. per unit = 5 5 0 per ton.

Kellier's second form of furnace, which was used by the Canadian Commissioners in their trials of Kellier's process at Livet, is also of the resistance type, and consists of four iron-cased shafts connected at the bottom by a horizontal canal leading into a central well. Each shaft is provided with a massive block electrode, movable either vertically or horizontally. At the bottom of each shaft there is also a large carbon block electrically connected. Refractory material is used for lining the shafts and the canal or bottom is of a basic material. The charge is of a similar character to that already described, and is inserted at the top of the shafts, gradually being lowered as the metals reach the molten state, when fresh materials are introduced. The metal is tapped at the central well, the slag being drawn off at a notch suitably placed.

Pig iron of varying analyses can be produced, the following being an example of the purest:

Total Carbon	4.200
Graphitic Carbon	0.800
Combined Carbon	3.420
Silicon	1.910
Sulphur	0.007
Phosphorus	0.027

The costs work out as follows:

E.H.P.-years per ton of pig iron	0.53			
at 0.075d. per unit	£1	1	3	per ton
at 0.35d. per unit	£4	19	2	per ton
at 0.45d. per unit	£6	7	6	per ton

Arc Furnaces.

The Stassano furnace is the best known of the arc type of electric furnaces, and the process differs from the Héroult and Kellier processes in that steel is produced direct from the ore in one furnace. There appears to be very little purification from sulphur and phosphorus, as the purest hematite ores are used. After the most careful analysis the ores are ground very finely and mixed with just sufficient fluxes to form a fusible slag and with just the necessary amount of carbon to effect reduction. This is then moulded into briquettes and these are charged into the furnaces. There is, of course, no combustion of carbon by free oxygen, and hence it is necessary to have all the materials ground and well mixed, and preferably combined in briquette form in order that the oxides may be in intimate contact. The rotation of the furnace also assists in maintaining this contact after the bath is molten. In the blast furnace there is, of course, considerably more carbon introduced, in the way of coke, than is necessary for the reduction of the iron, and the excess is consumed largely by the air which is introduced; but in the Stassano furnace, by very carefully adjusting the amount of carbon to just such a quantity as is sufficient to reduce the oxide, very pure iron, practically free from carbon, is obtained. It is claimed that in this process by increasing the carbon in the briquettes any proportion of carbon can be obtained in the steel, from soft steel to pig iron with carbon 4 per cent. and upwards.

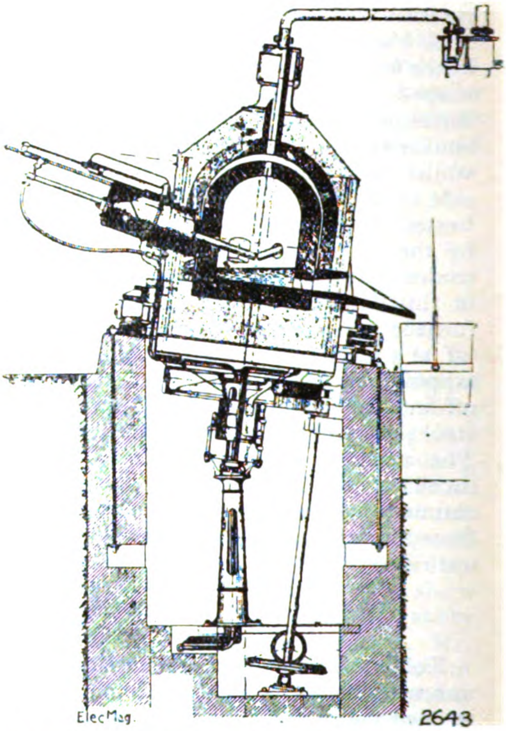
Captain Stassano was formerly in the Italian Artillery, and his early experiments were made in Rome in 1899. The furnace has been in operation at the Royal Arsenal, Turin. The earliest form of this furnace was identical in shape with the inside of a modern blast furnace, the electric arc connections taking the place of the tuyeres. This furnace was rotated with a very slight inclination from the vertical.

The modified form of rotating furnace which was erected at Turin has a circular dome-shaped melting chamber with three carbon electrodes instead of two, each operated by hydraulic cylinders, and in this case a three-phase current is used. This furnace is adopted for the production of either iron or steel. In the case of pig iron an excess of carbon is charged with the ore, but for steel just sufficient carbon is added to reduce the oxide of iron. At the Royal Arsenal, Turin, this furnace is used for the manufacture of steel shot for shells from iron and steel scrap, and is said to be giving every satisfaction.

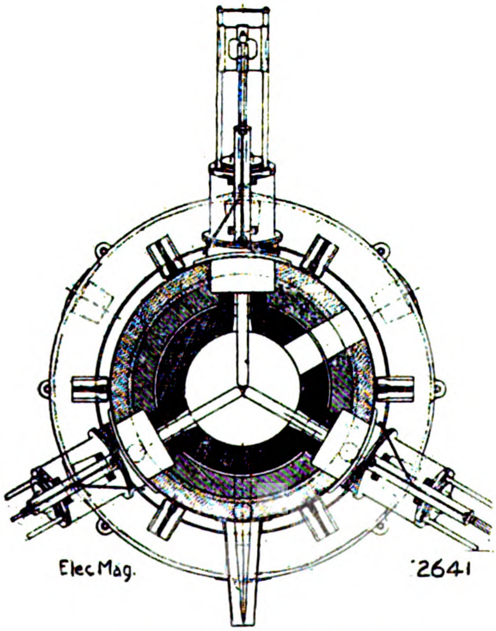
Captain Stassano has found from frequent trials that the power required to melt scrap is very much less than that consumed in the reduction of oxides of iron to the metallic state, and in order to still further reduce the consumption of electricity per ton of finished iron or steel he is experimenting with a new type of furnace, which in some respects resembles an ordinary Siemens-Martin steel furnace, having a fixed hearth. Also, believing that the more electrodes used in the furnace the greater the economy in the use of current, he is endeavouring to use two and even three pairs of electrodes for heating the charge by arc radiation.

The current consumption in the earlier types of this furnace are given as 0.186 e.h.p.-year per ton of steel, which gives the following costs per ton of steel at 40s. per e.h.p.-year :

at 0.075d. per unit	..	..		7	5 per ton.
at 0.35d. per unit	..	..	£1	14	7 per ton.
at 0.45d. per unit	..	..	£2	4	6 per ton.



Vertical Section of Stassano Rotary Furnace.



Horizontal Section of Stassano Rotary Electric Furnace.

This is a very low cost for smelting, and if it is still further reduced it will do much towards popularizing the electric furnace. It should be mentioned, however, that the wear and tear in this furnace appears to be much in excess of the other furnaces.

The following are typical analyses obtained with iron made direct from ore, and whilst the phosphorus is very low the sulphur is not so low as others quoted :

Carbon	..	0.120	0.092	0.113	0.091	0.090
Silicon	..	0.048	0.022	0.028	trace	trace
Sulphur	..	0.073	0.062	0.046	0.065	0.059
Phosphorus		0.0055	0.024	0.013	0.0016	0.009
Manganese		0.106	0.095	0.109	0.083	0.092
Iron	..	99.64	99.70	99.69	99.74	99.76

The usefulness of the electric furnace for melting is fully recognized, and the cost of electric energy alone no doubt prevents its more universal adoption. As a smelting furnace, however, its use so far seems to be limited to districts where there is a plentiful supply of water power near the ore fields, but no suitable fuel. Beyond doubt, the most successful of experiments to produce steel direct from ore have been made with the electric furnace, and in this respect there lies a great future before that smelting power which is still in its infancy.

EXHAUST STEAM POWER GENERATION.

W. G. TURNER.

(*The Author is connected as Assistant Engineer with one of the leading public electricity supply companies in the North of England, and has had practical experience in steel works electric power installations of the type described in this article.*—ED. E. M.)

* * *

In factories, collieries, and more especially in iron and steel works where the plant is generally driven by means of non-condensing reciprocating steam engines, exhausting to atmosphere, the utilization of the energy in the waste exhaust steam becomes a matter of considerable importance.

As this number of THE ELECTRICAL MAGAZINE is intended to deal specially with the iron and steel trades, the utilization of exhaust steam for power production will only be considered so far as it bears on these industries.

Although it is possible to electrify most of the smaller plant and non-reversing bar mills, &c., in a steel works it is still thought necessary to retain a large number of boilers to supply steam to the reciprocating engines, which drive the large reversing rolling mills, cogging mills, &c. Owing to the design, and the intermittent nature of the working of these engines, it has been considered an unnecessary outlay to provide an individual condenser for each of them. The immense size of a central condenser necessary to take the peak volume of steam and at the same time maintain a reasonable vacuum, is such as to render its installation prohibitive.

An enormous amount of exhaust steam from steel works and other engines is going to waste with more than one half of its available energy still left in it, which in these days must be considered a very serious loss. Large cogging mill and plate mill engines have an average consumption of from 20,000lb. to 40,000lb. of steam each per hour, and assuming that the total available consumption of steam in a given works is 50,000lb. per hour it can easily be shown that under such conditions an output of 1500kw. can be recovered by means of a good exhaust steam turbine and condensing plant. A reciprocating engine would not be able to deal economically and efficiently with this large volume of steam, as its cylinders would have to be of extraordinarily large dimensions, with the consequent extra losses due to friction and condensation.

The exhaust steam turbine, however, is able to expand the steam right down to the condenser pressure with the greatest efficiency. Under favourable conditions the vacuum may be as high as within 1in. of the barometer. The power recoverable from the steam increases very greatly as the vacuum becomes higher.

The exhaust steam turbine was first introduced and patented some years ago by the Hon. Charles A. Parsons, principally for use in conjunction with high-pressure turbines in marine work. In the "Mauretania," as a recent example, there are two exhaust turbines of nearly 10,000h.p. each.

The exhaust steam turbine is now being rapidly developed for land purposes, and it certainly would seem to have a great future before it as a waste-heat engine, in conjunction with existing reciprocating steam engines for the generation of electrical energy for supplying steel works both with power and light.

Although the writer is inclined to recommend the utilization of the exhaust steam from existing rolling mill engines by means of exhaust steam turbines rather than the conversion of the mills themselves to electrical driving he considers the complete electrification of rolling mills as distinctly promising and would advise every engineer before deciding on a new steam rolling mill plant to thoroughly investigate the possibilities of the electrical systems which have recently been adopted, more especially on the Continent.

The electric driving of large rolling mills can be accomplished with suitable apparatus to take the excessive fluctuations in the load of the mill. These fluctuations with a plate or cogging mill may vary from 0 to 8000h.p. or 10,000h.p. in a few seconds, and under ordinary circumstances it would be impossible to give a direct supply of electricity for such a purpose, even with the largest power plant, and at the same time maintain a constant pressure on the system. A flywheel converter is therefore interposed between the mains and the mill motor, in which the energy required to supply the momentary peak load is stored as kinetic energy in the flywheel, and is given up when required by its drop in speed. This reduces the effective top-load on the power plant to about one-tenth the amount, and so does not interfere with the pressure regulation.

The expenditure however required to electrify existing reversing rolling mills, taking into account the capital already invested in the engine, which in all probability would have to be "scrapped," and at the same time including the capital required for a suitable house for the electrical generating plant, would in many cases scarcely warrant the saving and conveniences which might be obtained by the conversion.

In steel works, where there are already boilers installed, the utilization of the exhaust steam saves further increase of this plant to meet extensions; and also makes the cost of production of electricity a comparatively small matter, the only real items in this cost being interest on capital expenditure for the necessary exhaust steam plant, depreciation, stores, wages and maintenance.

In many works the blast-furnace gases can be used for firing the boilers, thereby reducing the cost of coal for steam-raising purposes, and indirectly the cost of electrical energy.

The usual type of turbines employed for the utilization of exhaust steam is similar to the well-known high-pressure steam turbine, but proportioned to suit the conditions. Owing to the low steam admission pressure the turbine cylinder can be made much shorter. In this case, however, it requires to be larger in diameter in order to deal with the greater volume of steam; the blades must also be much longer, but the number of rows considerably less.

The principle of the steam turbine is now known to most engineers, but in case it should not be clearly understood, a short description of the Parsons low-pressure turbine which has been most largely adopted is given below :—

It consists of a cylindrical-shaped casing on the inside of which rows of inwardly projecting blades are fixed. A concentric shaft on the outside of which similar outwardly projecting blades are fixed is free to revolve inside this cylinder. The rows of shaft blades lie between those inside the cylinder, and the tips of each nearly touch the base portion of those opposite, the arrangement being that the steam will have to pass through a row of fixed blades and then a row of movable blades alternately, and with the least possible loss of steam due to clearance between the tips of the blades and either the casing or the shaft. In order to get the smallest possible clearances and at the same time avoid any possibility of damage to the blades by their coming in contact with the casing or shaft, the blades are thinned off at their tips—an arrangement which is found to be very effective.

The blades are curved in such a manner that the steam on entering the fixed row of blades is projected off at an angle in the direction of rotation upon the succeeding row of movable blades, giving them a rotational motion, the steam then being projected back on to the next row of fixed blades, this reaction helping to increase the rotational force. A similar action takes place as the steam passes each successive row of fixed and moving blades until it reaches the exhaust when it has been expanded down to the pressure of the condenser and has given up practically all its available energy to the turbine shaft The energy to give the steam the necessary velocity is supplied by the drop in pressure, the steam gradually expanding in small and regular increments as it passes through each successive row of blades. In order to counteract end thrust on the turbine shaft, a dummy piston and thrust block are arranged at the end of the cylinder on the same lines as those which exist in high-pressure steam turbines.

A sensitive centrifugal governor operating a steam relay, similar to that fitted to high-pressure steam turbines, is adopted for controlling the supply of exhaust steam to the cylinder. In case the supply of exhaust steam should fail or not be sufficient for the demands of the turbine, an automatic reducing valve is fitted by which live steam, reduced to about atmospheric pressure, can be supplied to the turbine. The turbine is also fitted with an automatic emergency governor which will close the main steam admission valve in the event of the speed of the plant exceeding a prearranged limit.

"Mixed pressure" or "mixed flow" steam turbines are arranged so that a supply of live steam can be used to either augment the supply of exhaust steam when the quantity available is not sufficient for the requirements of the load, or, should the supply of exhaust steam fail altogether, the live steam will be capable of dealing with the load. By this means the exhaust steam plant can be run efficiently at times when the rolling mills or other exhausting plant is shut down altogether.

The supply of exhaust or live steam is controlled automatically by means of special governor gear, operating double beat valves, which are arranged to regulate and control the admission of either pressure, or the lower pressure only, to suit the amount of exhaust steam available, and always run the turbine wholly on exhaust steam when the supply is sufficient.

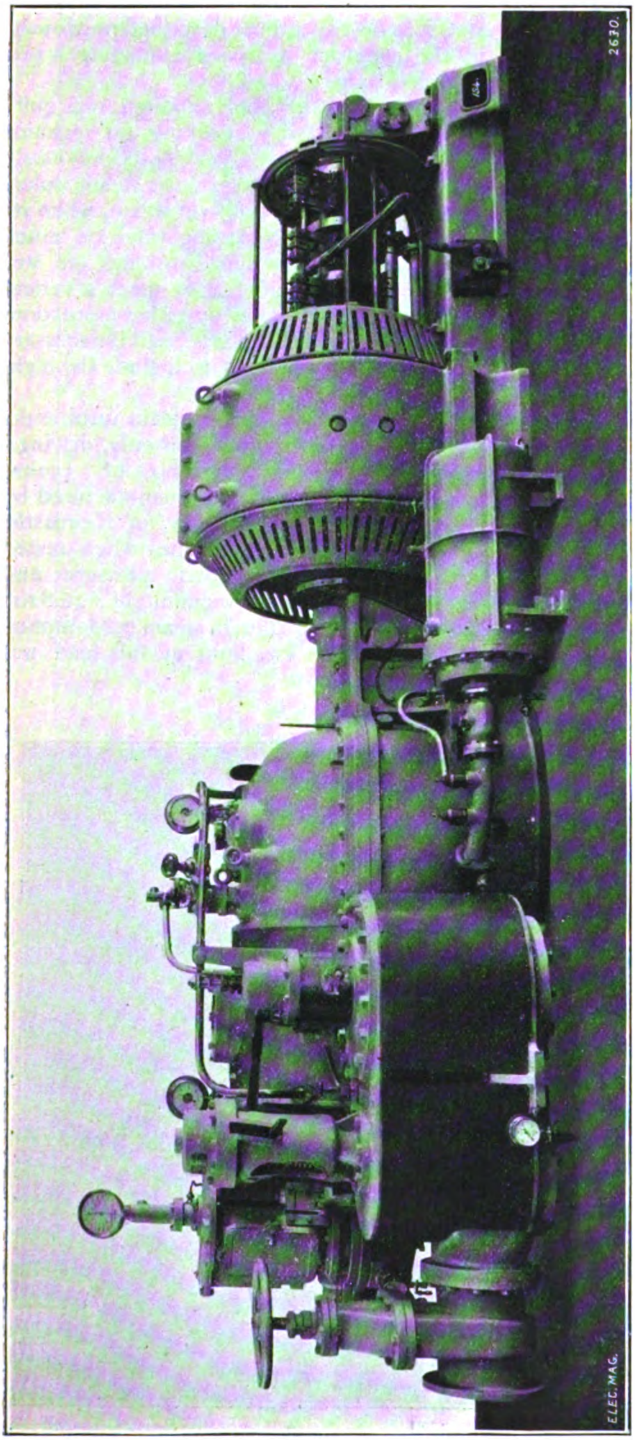


Fig. 1. 350kw. Exhaust Steam Turbo-Generator.

This form of "mixed pressure" turbine is arranged on similar lines to the usual high-pressure type, with the exception that it has a more elaborate governing gear and the exhaust steam is admitted at the beginning of the low-pressure portion of the cylinder. When the supply of exhaust steam is sufficient to meet the demands on the turbine, the high-pressure end is automatically cut out of action altogether, the steam being admitted to the low-pressure end only. At times the supply of exhaust steam may fail, or the load become too large for the amount available, and live steam is then automatically admitted to the high-pressure portion of the turbine to supplement the exhaust steam. As soon, however, as the exhaust steam becomes sufficient to meet the load, the supply of live steam is again automatically reduced and eventually completely cut off.

The supply of steam to either high or low pressure portions of the cylinder is controlled by a centrifugal governor so as to keep the speed of the turbine constant.

The turbine is also fitted with an automatic auxiliary runaway governor which acts on either of the steam admission valves, or simultaneously on the two should they both be in action, and shuts off all supply of steam, as on the turbine described previously, in the event of its speed exceeding a pre-arranged limit.

This type of turbine, although not quite so economical, when working on exhaust steam only, as that described previously (which is designed for exhaust steam solely and takes its supply of live steam, when required, through a reducing valve) is much more economical when working on live steam, and is better able to meet a variety of conditions. It takes up rather more room than the purely exhaust type, as it is necessary to have a longer cylinder to include the high-pressure portion.

Fig. 1 shows an exhaust steam turbine designed for low-pressure steam only, driving a continuous - current dynamo of 350kw. capacity at 220 volts, as manufactured by Messrs. C. A. Parsons & Co., of Newcastle-on-Tyne. With this turbine, when tested with steam at atmospheric pressure and exhausting into a vacuum of 26.82in. (barometer at 29.46in.) a steam consumption of 40.83lb. per kw. hour at full load was obtained.

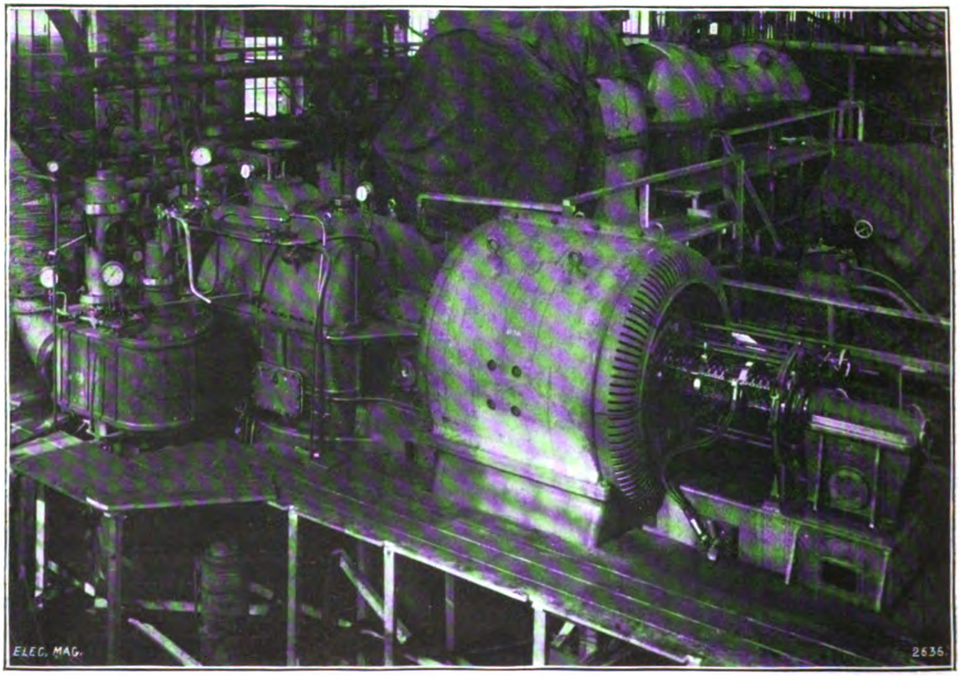


FIG. 2. 750KW. EXHAUST STEAM TURBO-GENERATOR.

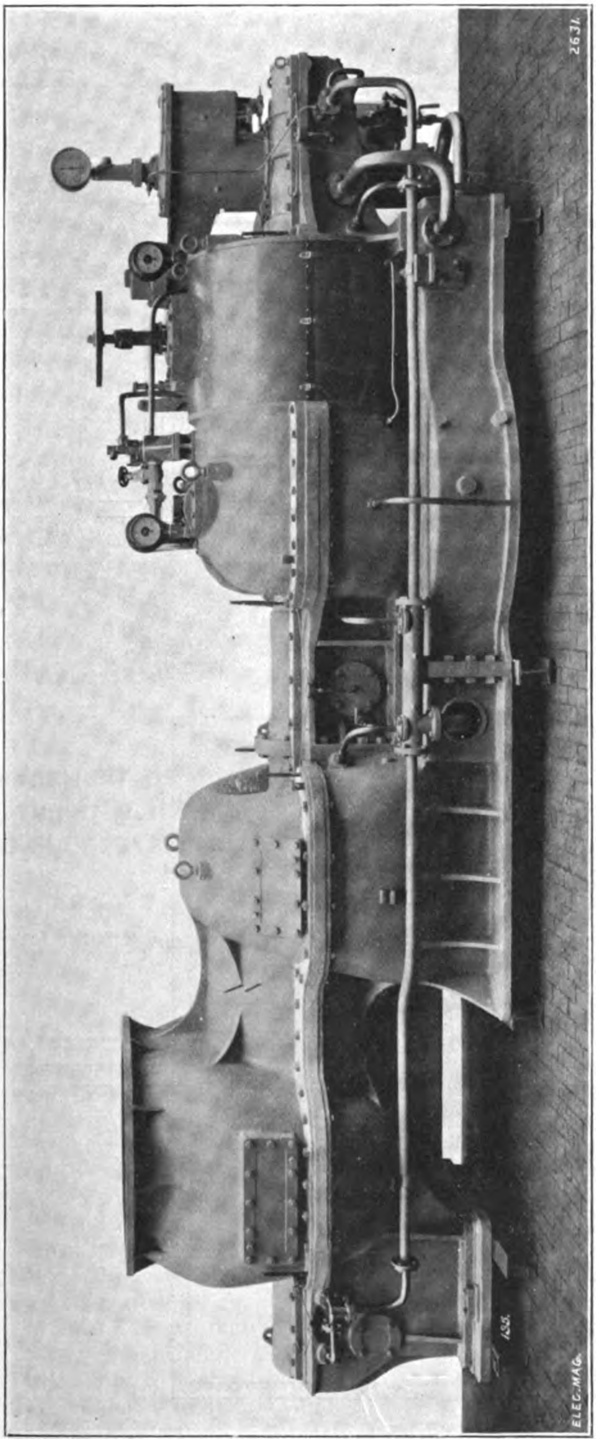


FIG. 3. EXHAUST STEAM TURBO-BLOWER.

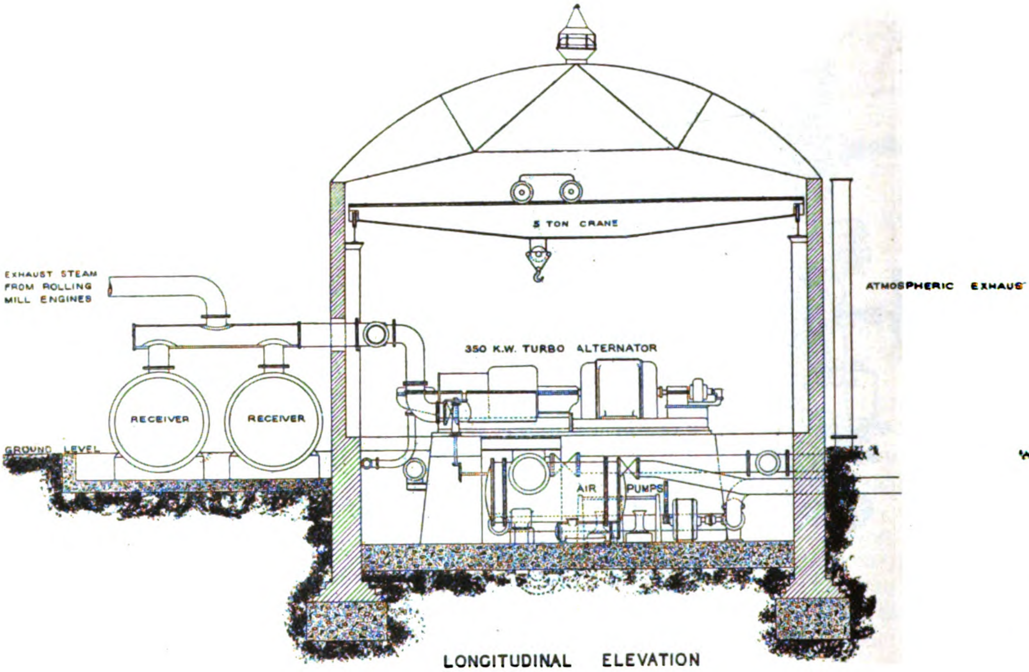
Fig. 2 shows an exhaust steam turbine similar to the above but with an output of 750kw. at 480 volts; this turbine has a consumption of 30lb. per kw. hour at full load with a vacuum of 29in. (barometer at 30in.), and is at present in Messrs. C. A. Parsons & Co.'s test house.

Fig. 3 shows the application of an exhaust steam turbine to driving a turbo-blowing engine for blast furnace working. This plant was designed to work with exhaust steam at 18lb. to 20lb. absolute pressure, and when tested at Messrs. C. A. Parsons & Co.'s Heaton works, with a steam pressure of 3lb. per square inch above atmosphere and with a vacuum of 28in. (barometer at 30in.), a total steam consumption of 14,600lb. per hour was obtained, the output being 14,000 cubic ft. of free air at a pressure of 6lb. per square inch.

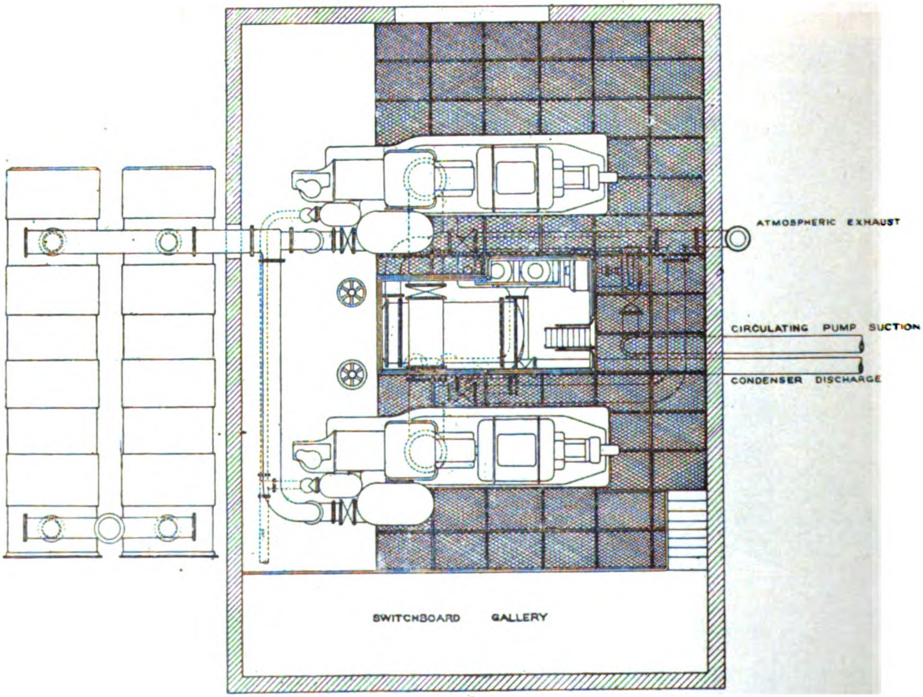
As the supply of exhaust steam from engines driving rolling mills of either the reversing or non-reversing type and other steel works machinery is generally very intermittent, it is necessary in some cases to provide some form of steam receiver or accumulator.

Usually where the exhaust steam supply is fairly constant a receiver consisting of old Lancashire boiler shells suffices to steady up the pressure sufficiently for all practical purposes. In extreme cases, however, it may be necessary to resort to the thermal regenerative accumulator, by means of which a comparatively steady supply of steam can be maintained even though the reciprocating engines may be completely stopped for, say, an interval of five minutes.

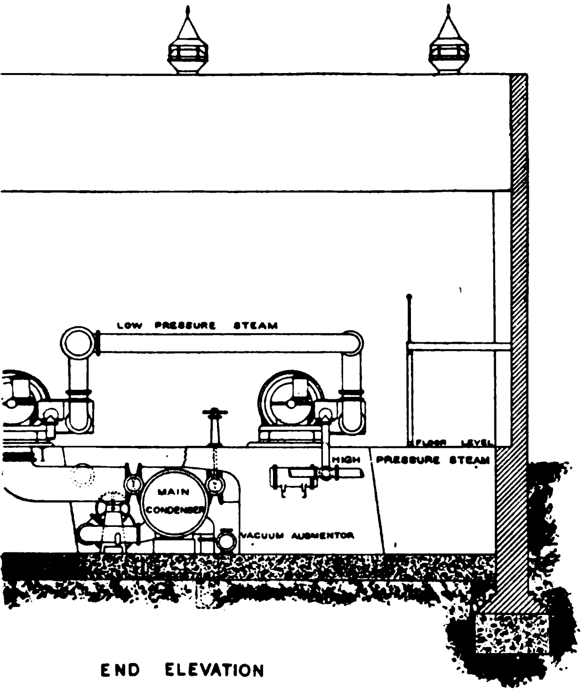
In order to be successful in operation and yet be a commercial possibility the regenerator must have a large heat



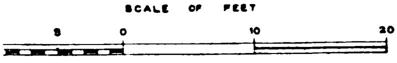
LONGITUDINAL ELEVATION



ELEC MAG PLAN 2637.



ARRANGEMENT OF
350 K.W. TURBO ALTERNATORS
MIXED FLOW TYPE.



storage capacity and be capable of absorbing and giving out heat very rapidly, yet at the same time it must not be large or costly.

There are several types of accumulators on the market, but the most satisfactory type appears to be that consisting of large shells half filled with water through which the exhaust steam passes on its way to the turbine. Water in a stationary condition, however, is a bad conductor for the rapid interchange of heat. It is therefore necessary to lead the steam in under the water in such a manner as to maintain the latter in a state of violent circulation, thus keeping the steam and water in constant contact with one another. This accumulator generally consists of horizontal cylindrical steel shells, the capacity being dependent upon the output of the turbine to be supplied. The duration and amount of steam to be dealt with also have to be taken into consideration.

There are various means of keeping the steam and water in intimate contact and active circulation. In the "Rateau" type of accumulator the steam is introduced into it through perforated elliptical-shaped tubes placed below the water level.

The holes in these tubes are arranged so that the action of the steam flowing through them creates an active circulation of the water. Baffle plates are suitably arranged and fixed in the steam space above the water in order to prevent water in the form of spray (which would be equivalent to priming in an ordinary boiler plant) being carried over into the turbine. A ball float valve with a tank is arranged outside the vessel to keep the water at a constant level.

The result of this action of the steam coming in contact with the water is that the latter is heated up to boiling point, determined of course by the pressure inside the accumulator. This occurs when the supply of steam is in excess of the demand, the balance being discharged to atmosphere through a relief valve. As soon, however, as the demand exceeds the supply the pressure in the accumulator falls, the water then liberates the heat it has absorbed, and in evaporating gives off an even flow of steam to make up for the deficiency. When the supply of steam ceases altogether the pressure in the accumulator is still further lowered, which allows the steam contained in the exhaust pipes to be liberated, thus keeping up the circulation of the water and assisting in the evaporation. As one might expect, there is a slight back pressure in the regenerator owing to the holes in the tubes being under the water, but this is reduced as the water becomes steam - saturated. The steam to the turbine is taken away from the top of the regenerator, another baffle being arranged inside opposite the outlet as a further precaution against water being carried away in suspension with the steam.

It is usual to fit a non-return valve on the inlet pipe of this type of regenerator so that water cannot be carried back to the engine in the event of the latter stopping.

The regenerator and receiving vessel may be covered with some insulating material in order to prevent the rapid radiation of heat from either of them. A relief valve is also fitted by means of which the pressure in the regenerator can be regulated and allow of the escape of steam when the turbine is on light load, or is shut down altogether.

As previously mentioned, a well-designed regenerator should be capable of supplying the turbine with steam for intervals, say, of five minutes, but this figure may not meet all cases, and each should be studied individually on its own peculiarities and merits.

It is advisable to fit a receiving vessel to the exhaust main between the reciprocating engines and the regenerator to provide for the easy escape and expansion of the steam from these engines without putting any back pressure on them. At the same time this receiver will help to steady up the flow of steam to the regenerator. The receiving vessel can be about one-half the volume of the regenerator and it will also be found advantageous if it is fitted with a series of baffle plates.

If the condensed water is to be used for boiler feed water, which is possible where surface condensers are adopted, and at the same time to prevent the interior of the regenerator from being coated with oil, it is advisable to fit an oil separator. The usual type of oil separator consists of a series of narrow vertical curved or V-section baffle plates with their hollow sides facing the direction of the flow of the steam. These are arranged in rows and staggered in such a way as to present a good area and cause the steam to be constantly changing its direction of flow to find its way past them. The particles of oil which may be held in suspension in the steam hit up against the baffles, to which they adhere. After draining to the bottom of the vessel the oil can be drawn off by means of suitable drain cocks. It is possible to make the oil separator of sufficient capacity to act as a steam receiver, or the steam receiver can be arranged as an oil separator, thus making one vessel serve the double purpose.

A high vacuum is of great importance with an exhaust steam turbine, and it is advisable to have a good supply of cooling water at a low temperature.

The condensers should preferably be of the surface type, with which it is possible to maintain a high vacuum and also to save the condensed steam, which can be used over again for boiler feeding purposes, as stated previously. A vacuum augmenter to be used in conjunction with the surface condenser has been designed by Messrs. C. A. Parsons & Co., and is of much service in increasing the vacuum. It is possible to effect a saving of over 39 per cent. in the steam consumption by increasing the vacuum from 26in. to 29in. of mercury, the barometer being at 30in.

The continuous-current generator, or alternator, as the case may be, must be directly coupled to the turbine and the system of generation and distribution should be chosen to suit individual cases. Fig. 4 is a typical arrangement of an exhaust steam generating station showing two 350kw. exhaust steam turbo-alternators of the mixed-flow type exhausting into a common condenser. It also shows very clearly the arrangement of receivers, consisting of old boiler shells and exhaust pipes.

A few words as to the saving in capital expenditure and cost of production of electricity by the adoption of exhaust steam turbine plant as compared with high-pressure plant may be of interest. With a high-pressure plant of 1000kw. output having a consumption of 18lb. of steam per kw. hour, or a total of 18,000lb. of steam per hour, it would be necessary to install at least four boilers of the Lancashire type, one to act as a spare to allow for another being laid off for cleaning purposes. These would cost £2400, and to this figure must be added a sum for boiler house, seatings, flues, and possibly a new chimney, bringing the total up to, say, £3200. This price can be compared with that of the exhaust steam regenerator. For a similar capacity the cost would be about £2000, including foundations, &c., which gives a clear saving in favour of exhaust steam plant of £1200. The capital cost of a high-pressure turbine plant with its buildings, auxiliaries, and spares comes to about the same as that of the exhaust steam installation, but if the high-pressure plant is of the reciprocating type it would cost about 20 per cent. more, principally on account of extra foundations and larger building.

Of course in the majority of cases it is not necessary to fit a regenerative accumulator and there would be a clear saving equal to the total cost of the boiler plant. Simple receivers, as previously stated, can be made from old boiler shells, which can be procured for scrap prices and as a rule are to be found ready at hand in most steel works.

The saving in working cost due to the utilization of exhaust steam is enormous, there being no extra cost of fuel as long as the main engines are running, and there is also the saving in the cost of firing which would be necessary with the extra boilers required for high-pressure steam electric generating plant.

The saving in coal and firemen's wages for one year would be approximately as below:—

Supposing the plant works ten hours a day and 300 days per year and has a 0 5 load factor. Then if 1kw. requires 3.5lb. of coal per hour, the amount of coal per day would be approximately 7.8 tons, or 2340 tons per year. This at 12s. per ton would cost, say, £1400. The saving in labour for two firemen at 30s. per week each would be £156 a year, making a total saving of £1556 per annum. To this figure should be added a sum representing the saving in interest and depreciation on the difference in cost between the boilers required for high-pressure steam-generating plant, and the regenerator which may be required for exhaust steam plant. The difference in cost in the example given previously was £1200, and allowing interest and depreciation at 10 per cent. per annum, this would amount to £120, which, added to the saving in coal and wages, would make a total saving of £1676 per annum.

If it be found that a regenerator is not required there will be a corresponding clear saving in interest and depreciation on the total capital cost of the boiler-house plant, which would still further increase the balance in favour of the exhaust steam system of power generation.

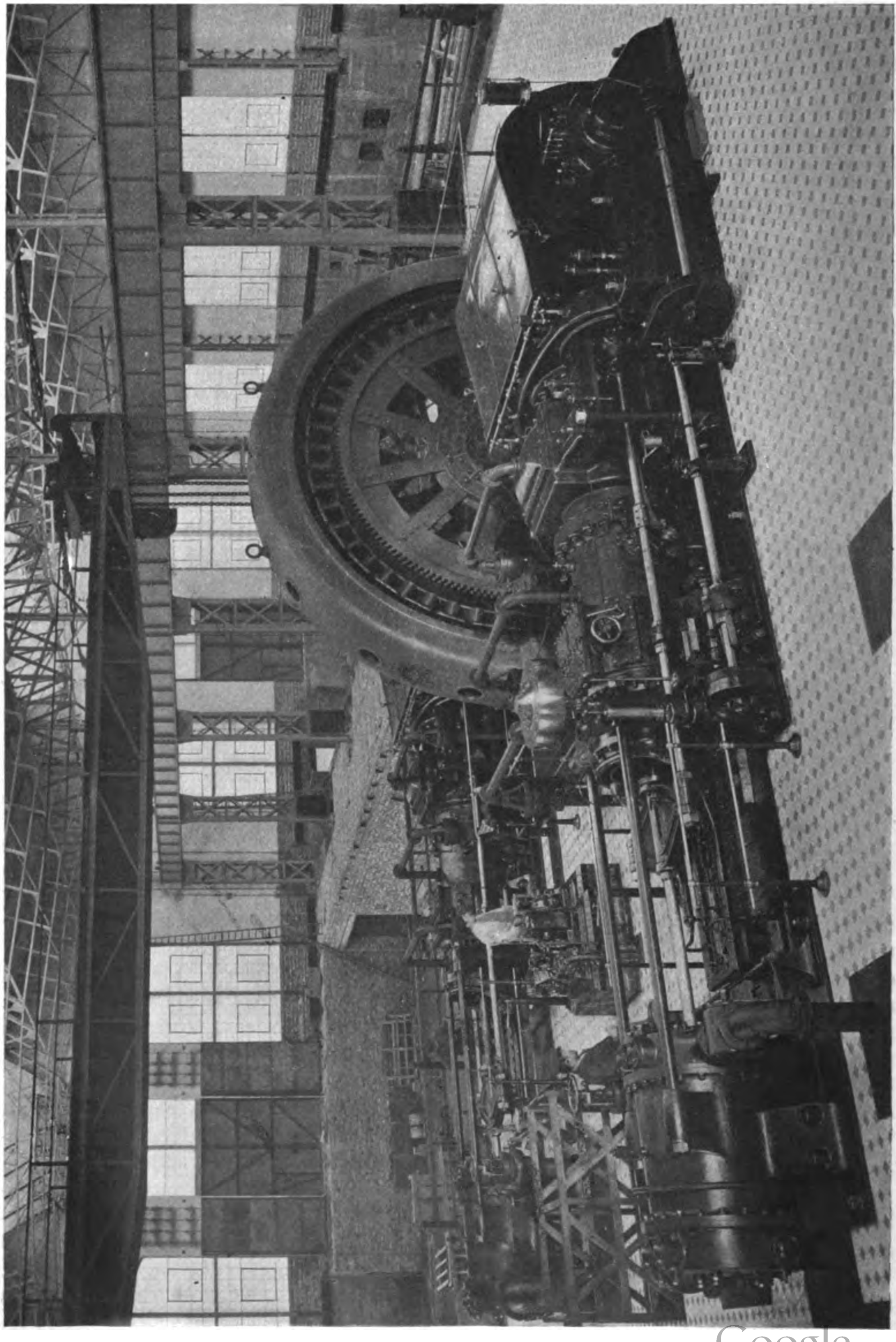
* * *

APPLICATION OF ELECTRIC POWER IN THE PRODUCTION OF PIG IRON.

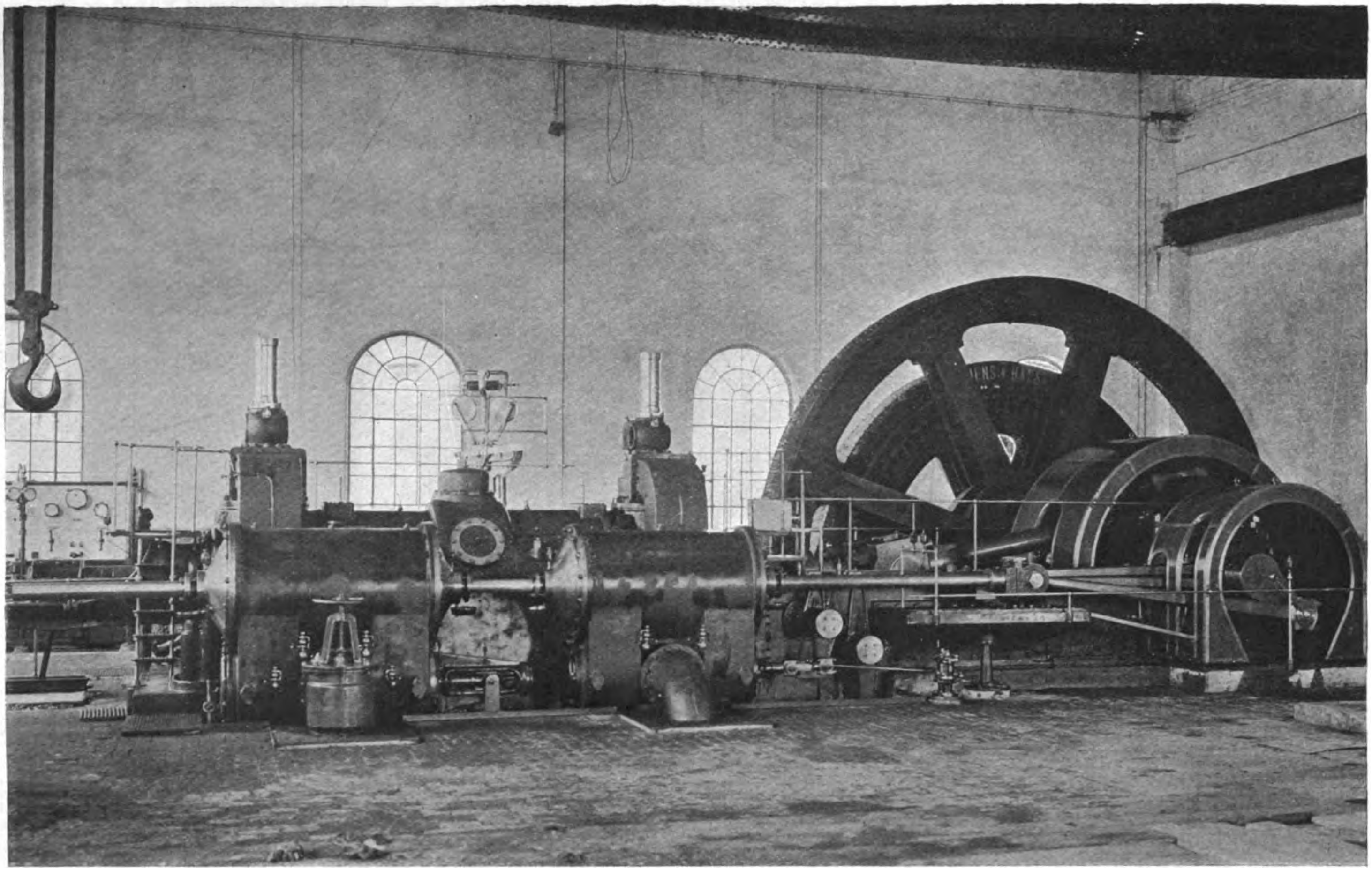
S. P. BOWEN.

(*Mr. S. P. Bowen is the manager of the Tees Bridge Iron Works, Stockton-on-Tees, and has for many years been engaged in iron and steel works practice at some of the most progressive works in the Cleveland district.*—Ed. E. M.)

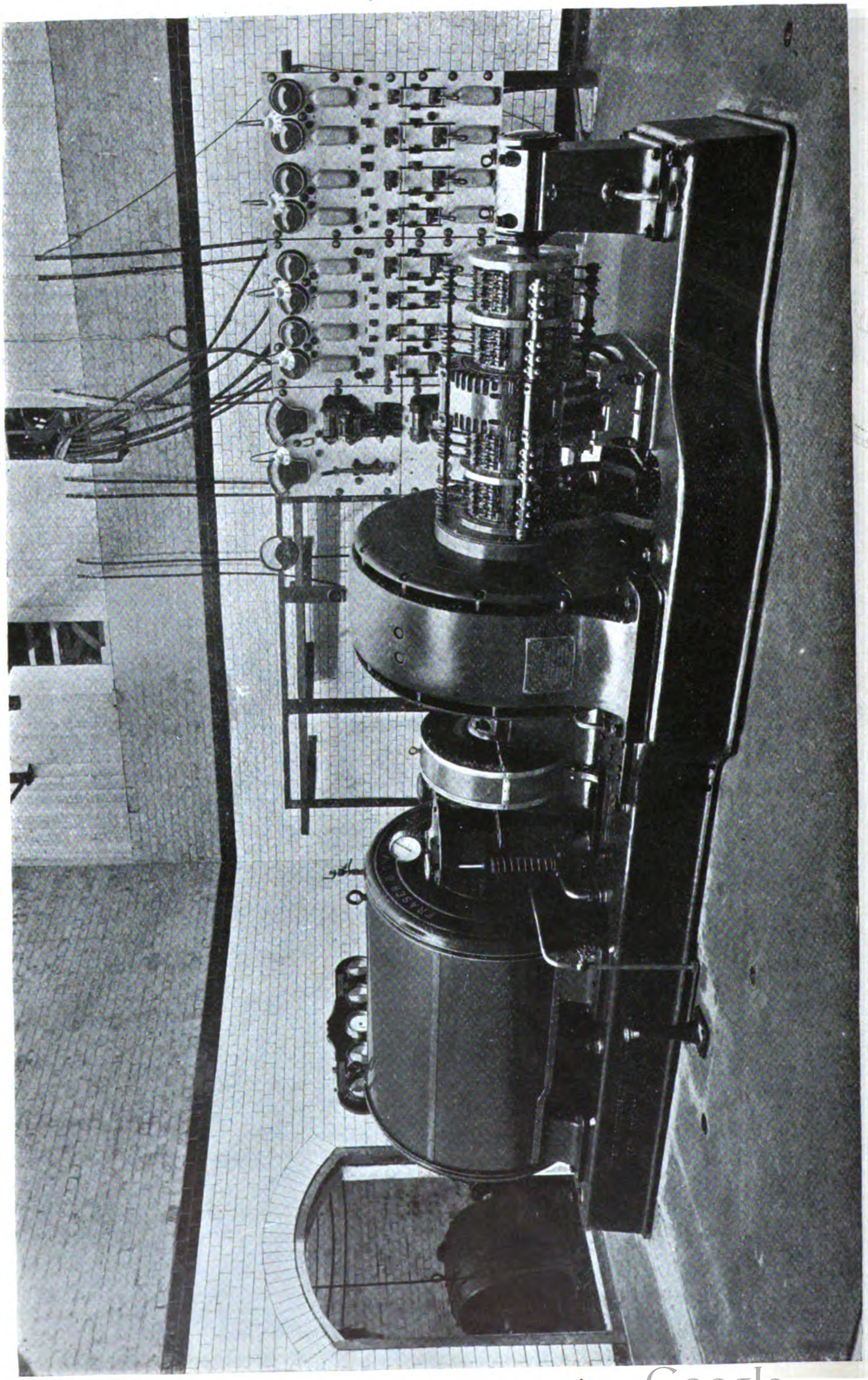
In the manufacturing processes of to-day we are constantly called upon to consider cost of production, and one of the questions to be thought out is the application of electric power as affording a saving in labour and also economy in the use of the waste heat from blast furnaces. This question has received considerable attention during the last few years both as regards the production of the power and also the application of the same to the various plant employed at the works. In approaching this question the works engineer is confronted with the problem as to whether it will pay him to put down generating plant and produce on the works the necessary power by the installation of gas or steam engines or whether it would be to his advantage to purchase power at an equivalent cost from the public electric power generating company. These alternative propositions are no doubt before the minds of most engineers at the present time and require a considerable amount of thought before finally fixing on the most suitable arrangement for the particular case under consideration. The conditions under which the power would have to be generated and the amount of power required have also considerable bearing on the subject. Taking the case of blast-furnace plants directly connected with coke ovens and steel works producing finished steel sections, this is the ideal case for the adoption of a large power plant driven from the waste heat either by means



One of the Oechelhäuser-Siemens-Schuckert Gas-Engine Generating Sets in the Central Station of the Ilseder Hütte at Peine, near Hanover. There are two such sets, each having a capacity of 1,000H.P., three-phase, 10,000 volts, 50 periods, 125R.P.M. The engines are driven by blast-furnace gas. The station is being extended by the installation of two more sets, each of 1,600H.P. capacity. The power is used chiefly for mining machinery at a distant pit, for pumps, and at the Peine Steel Mills.



One of three Körting-Siemens-Schuckert Gas-Engine Sets in the Central Station of the Gutehoffnungshütte in Oberhausen. Each set has a capacity of 1,000h.p., three-phase, 3,000 volts, 71r.p.m. There are also several other gas engines in the station, all of which are driven by blast-furnace gas. The station is for supplying power for an 1,800h.p. motor driving a plate mill, 1,500h.p. motor driving a bar mill, 1,800h.p. motor for driving a rail mill, and about 1,500h.p. distributed among various motors for driving live rolls, pumps and auxiliary machinery about the steel mill.



A Rateau-Siemens exhaust steam turbo generating set, capacity 450kw., 230 volts, continuous current, 1,500r.p.m.
This set is now running at the works of the Steel Company of Scotland, Ltd., in Glasgow.

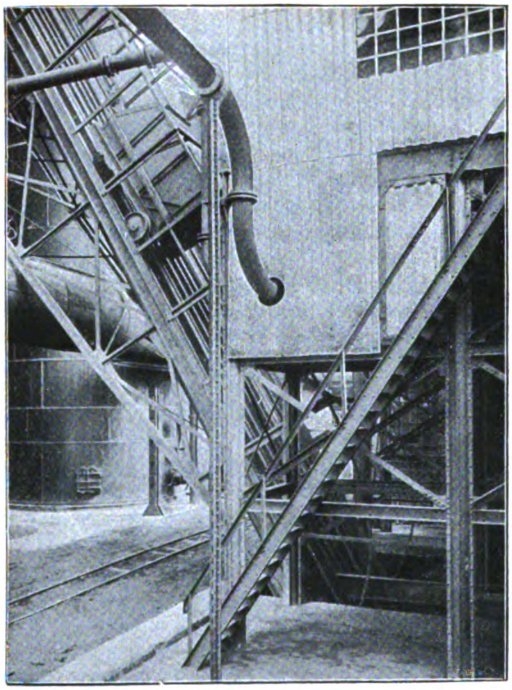
of gas engines supplied from furnace and oven gases or by exhaust steam turbines where the driving plant for the furnace blowing engines, rolling mills, &c., is of the steam type and non-condensing. But in blast-furnace plants where no steel works or coke ovens exist, or where the adoption of an electric power plant would appear at the present time a doubtful saving, owing to the small amount of mechanical power necessary to handle the material used in the process, it would probably be more economical to purchase the power at a reasonable rate from the local electric power company. In the adoption of any power plant careful calculations require to be made bearing on the point of cost of producing the necessary power; it would appear that in many instances where the generating plant must of necessity be in duplicate—for reasons of breakdown risks, repairs, &c.—with a load factor of probably only 15 to 20 per cent. of the total plant installed it would be more economical to purchase the power required. Of course this decision depends on the supply company's charge per unit, but the author has in mind the average prices which prevail in the iron and steel works districts of this country. As influencing the choice of the method to be adopted for producing the necessary power, great importance attaches to the question of capital outlay, especially on plants at present in operation which have adopted steam blowing engines. To produce sufficient power from the waste gas for operating the steel works, &c., it would be necessary to put down gas-driven blowing engines, thereby leaving sufficient spare gas for the gas-electric power-generating plant. This is the only method to adopt when the largest amount of power it is possible to produce from the waste gas is required, but the serious items of interest and depreciation on such an equipment cannot be overlooked. Moreover practice teaches that there appears to be room for considerable improvement in the design of the gas engine, particularly with regard to its mechanical arrangement and general reliability.

In smaller plants where the outlet for electric power is limited, the system most suitable appears to be the exhaust steam turbine arrangement, but this applies only to those works where sufficient exhaust steam is available from the existing blowing engines; there is, as a rule, an ample supply of exhaust steam and quite sufficient to produce all the power required for operating the plant, the average power supply on this system amounting to about 500kw. hours for each 100 tons of iron made per day.

The general application of electric power in the production of pig iron is gradually forcing its way, and although in some installations the actual saving expressed in so many figures by the change from steam to electric drive appears small, there are no doubt considerable advantages in many other directions. There are many places in the iron-making process where the application of electricity has and can be most economically adopted, although it must not be overlooked that as a rule the blast-furnace plant is run without the use of any coal whatever as a means of producing mechanical power, and therefore no saving on this head can be looked for. At most works on the arrival of the raw materials, either at the wharf or on the railway sidings, considerable handling and moving of the supplies is necessary and it requires a large amount of study to economize in this. This is especially the case with the older works and in many of these cases it would be possible to adopt mechanical conveying of the materials with the certainty of a great saving as the result.

Taking the case of minerals arriving at the works siding in certain plants, the wagons are lifted by means of a steam hoist on to a gantry along which they run on rails by gravity over the kilns and bunkers, into which they are discharged by men; the trucks are then lowered at the other end of the gantry by a drop to the ordinary rail level; this entails a large amount of labour, and by a skilful arrangement some method of electrically driven endless belt might be used, the minerals being first tipped into a large hopper on the ground level and thus fed on to the belt which would run the full length of the gantry. The conveyer would be fitted with an arrangement so as to tip the materials into any kiln or bunker as desired—this would allow of using wagons of large capacity, as they would not then require to pass over the gantry; the system should show a considerable saving in labour.

Also, with reference to the material received by steamer alongside the wharf, a promising scheme would be the adoption of electric long-span cranes or some similar arrangement coupled with a telpherage system whereby the ore discharged from the steamer could be stocked in a general ore-storage



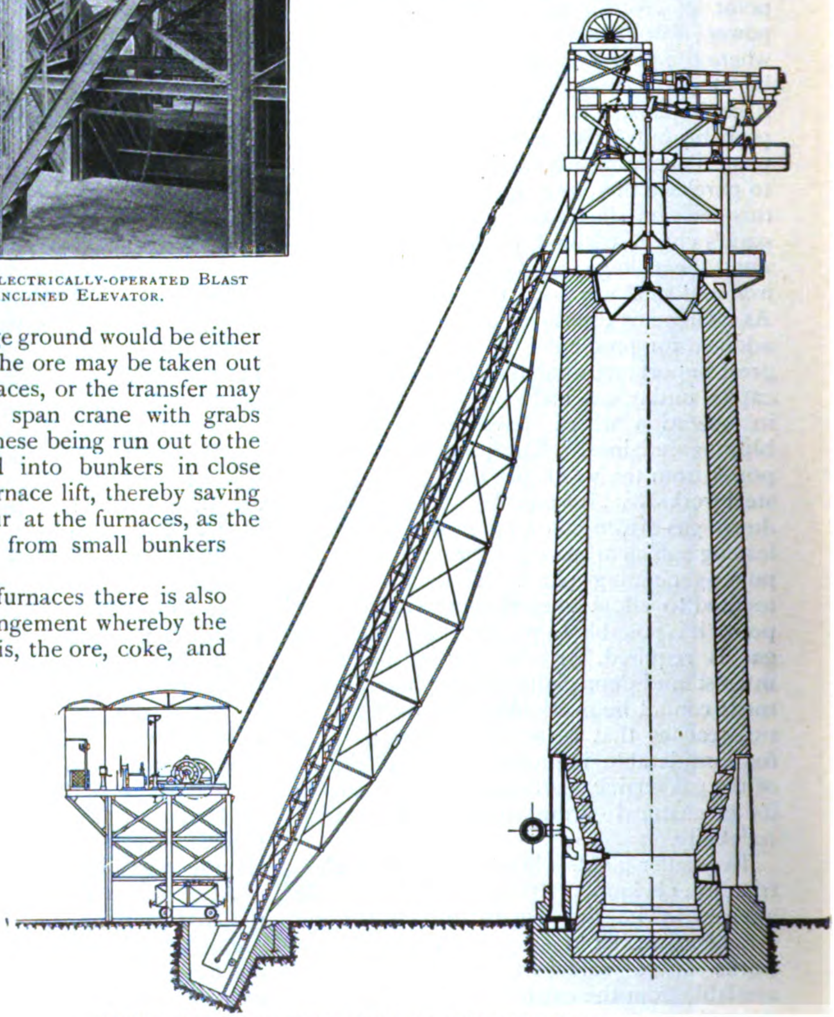
View at Foot of Electrically-operated Blast Furnace Inclined Elevator.

ground. The storage ground would be either tunnelled, whereby the ore may be taken out and sent to the furnaces, or the transfer may be by an overhead span crane with grabs filling into trucks, these being run out to the furnaces and tipped into bunkers in close proximity to the furnace lift, thereby saving a good deal of labour at the furnaces, as the men can fill direct from small bunkers near at hand.

In or about the furnaces there is also scope for some arrangement whereby the raw materials—that is, the ore, coke, and limestone—could be collected from the different points, weighed, and put in close proximity to the furnace lift. This method can be conveniently arranged for on an entirely new plant, but the fitting of such a system for this purpose to an existing old plant is a very different and much more difficult matter; in any case a successful transporter system, to serve these purposes, would be eagerly sought after.

Having the raw materials centred at the bottom of the furnace hoist, one comes to the consideration as to the type of lift to adopt for raising them to the top of furnace, and with this comes the question of the best method of furnace charging.

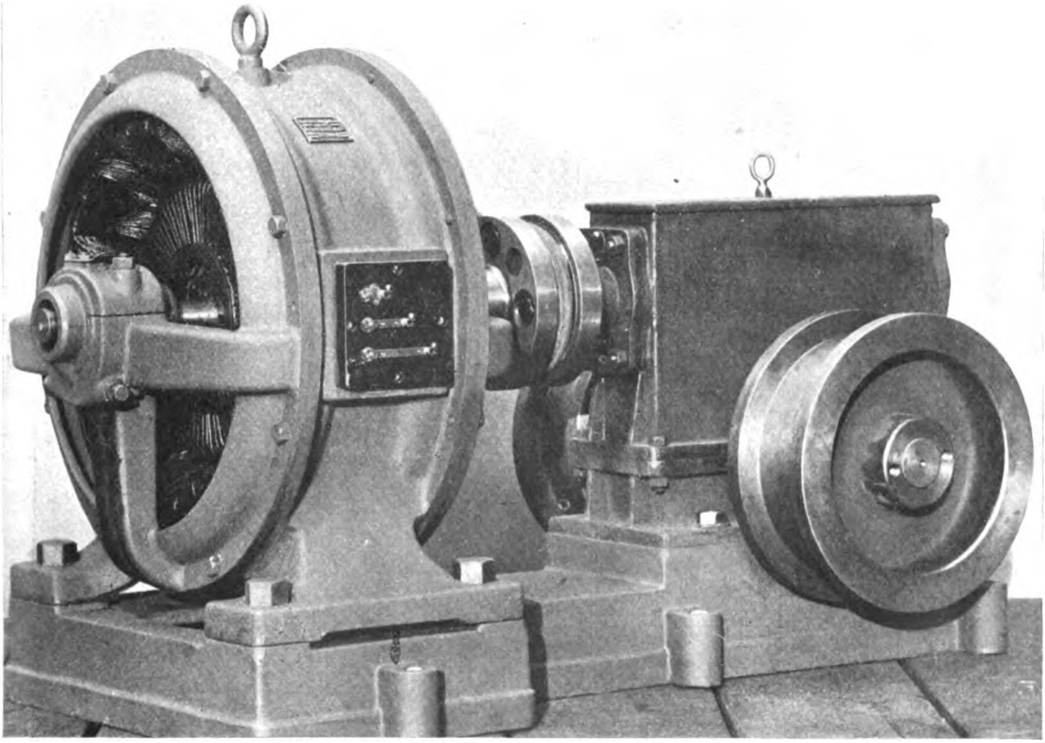
There is great divergence of opinion as to the merits and demerits of the mechanical charging of blast furnaces, and considerable anxiety has been caused in some cases by the indifferent working of the furnaces after the



General Design and Arrangement of an Inclined Electric Elevator as adopted at a German Iron Works.

adoption of the so-called self-charging method. This system is generally carried out by an incline runway carrying one or two skips. These skips are fed by hand or some mechanical feeder and hold from 3 to 5 tons of materials; they are drawn up the incline runway to the top of the furnace and discharged into the hopper, the charge being then fed into the furnace by lowering the bell. This system of charging appears to be the right thing, the trouble with it being due chiefly to the uneven disposition of the materials on being discharged into the hopper. The large materials tend to all go to one side of the furnace and produce a very irregular and uneconomical working of the furnace. This has been overcome to a large extent by modifying the system, whereby the materials are deposited in different parts of the hopper so that the furnace receives the materials, large and small, evenly all round. There is, however, another very important point of the self-charging method to consider, and that is the disadvantage of the repeated and heavy dropping of the coke; this applies to any mechanical arrangement for conveying the minerals, and care must be taken in designing such equipments to avoid the constant tipping of the materials, more especially the coke, owing to its soft and friable nature.

The application of the electric drive has been carried out on the usual vertical furnace hoist with satisfactory results, although, owing to the lift cage having to stop within the limit of 1in, considerable trouble was experienced in the early designs. This can now be done most accurately, especially where a direct-current motor is used for the purpose, and with a proper installation. This consists of a motor generator running constantly, the armature of the generator being connected in series with the armature of the hoist motor. The field of the generator is controlled by a small rheostat placed conveniently about the furnace lift, by which a varying voltage is applied to the armature of the hoist motor.



A Standard Form of Electric Winch used for operating Blast Furnace Bells.

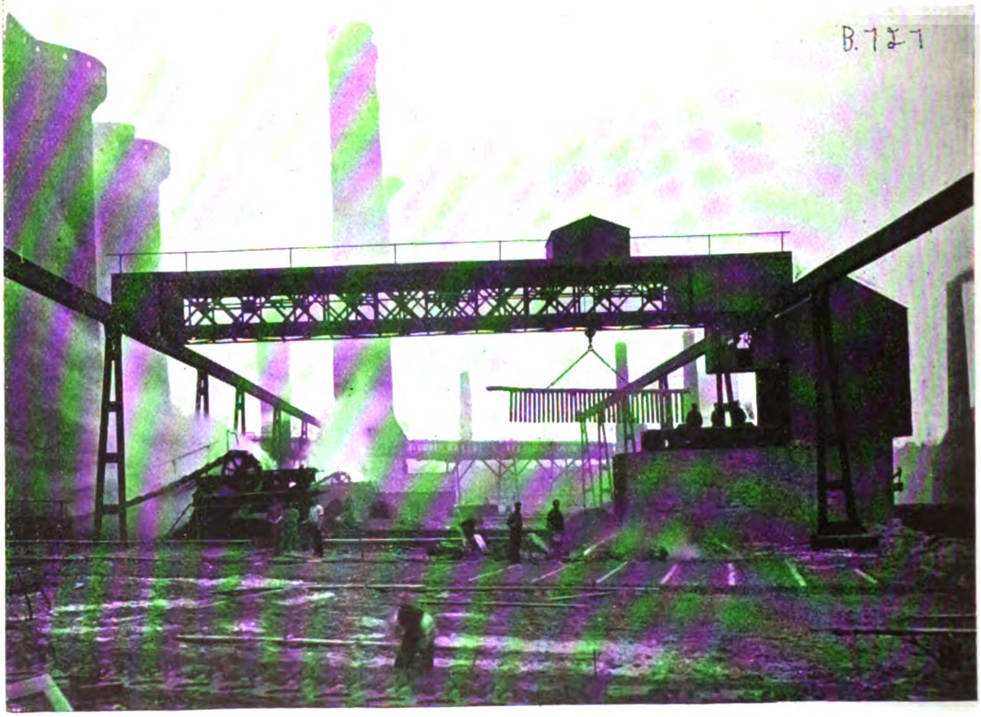
By this means the speed of the hoist motor is governed automatically, the rheostat being placed on the hoist guides, and to the cage are fixed cams which automatically shut off the rheostat and reduces the speed of the cage as it approaches its stopping point. At the instant the cage reaches the top of the furnace, the cam forces the rheostat handle to the off position, entirely breaking the circuit and at the same time applying a holding brake.

This method is simple and requires no skill on the part of the operator, but it is somewhat more expensive in first cost than the ordinary controllers and solenoids for actuating the different resistance contact steps, which, however, waste considerable current at each start by the losses in resistance and have the disadvantage of not giving a certain means of stopping the cage at the exact point. These lifts can be worked by the ordinary furnace man thus dispensing entirely with the usual lift driver and introducing a saving of three men per twenty-four hours.

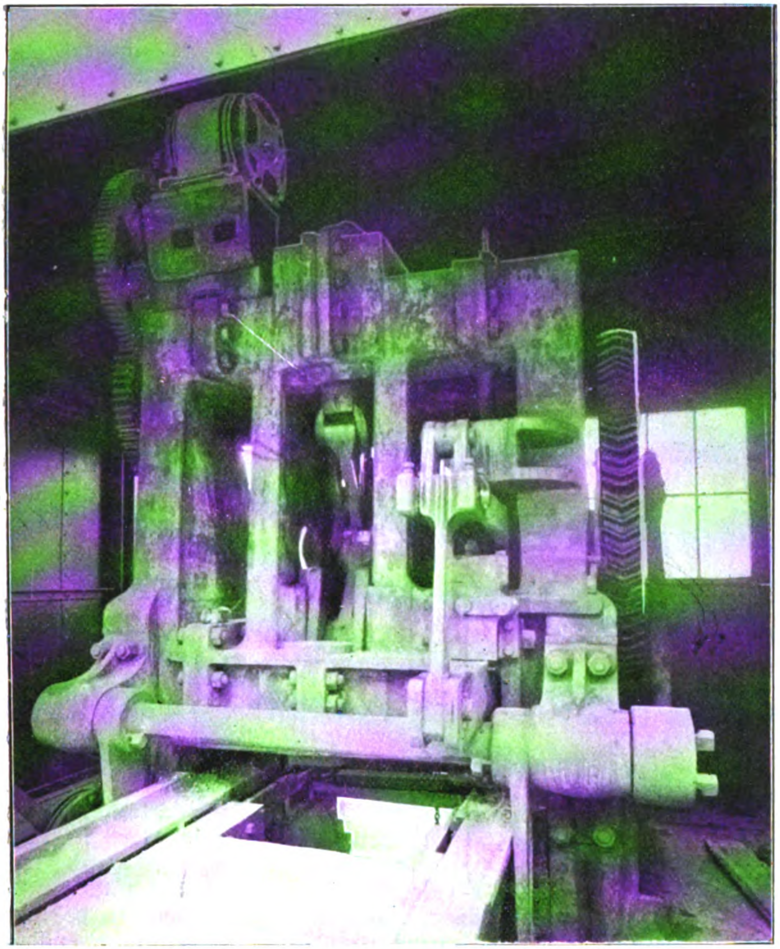
The application of the motor-driven winch for operating the blast-furnace bells has been carried out most successfully and overcomes the trouble of bells sticking with the resultant loss of gas and stopping of the charging operations at the top of the furnace. The electric arrangement, being automatic, allows the chargers to attend to other work whilst this operation is carried out, or in more modern plants, with self-charging, the lowering of the bell is carried out from the cabin of the man operating the lift, entirely dispensing with manual labour at the top of the furnace.

The question of removing the pig iron from the pig beds has had considerable attention during the last few years, and many successful arrangements have been put down showing very great saving. The method adopted has varied in some respects, some adopting the overhead long-span crane and others the usual jib crane, both being carried on runways fixed along the pig beds.

The three-motor long-span crane is the type to be preferred for this purpose, although the cost is slightly more; the jib crane is limited in its uses, whereas with the



A THREE-MOTOR, THREE-PHASE OVERHEAD TRAVELLING CRANE SERVING PIG-BEDS.



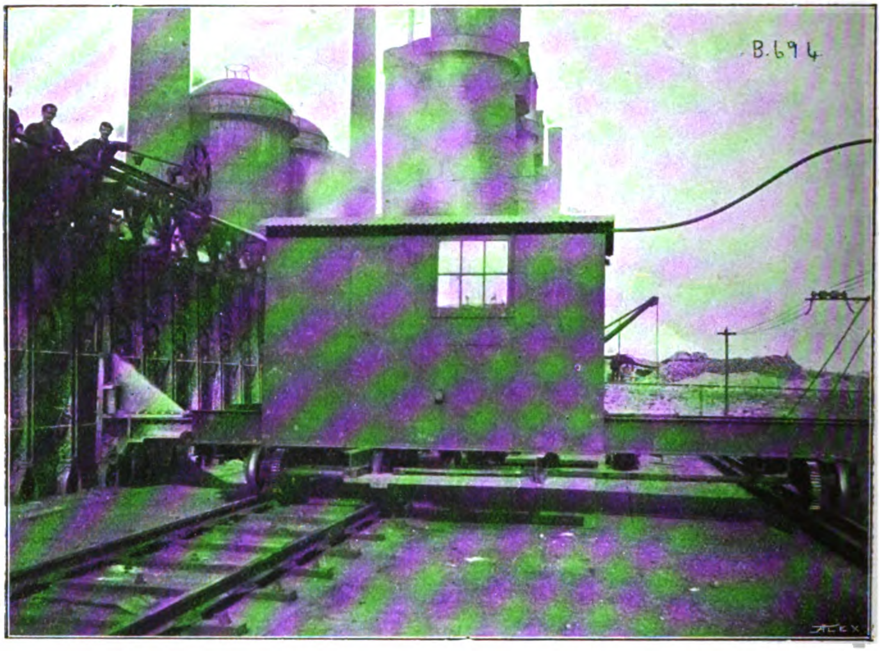
An Electrically-driven Pig-breaker, fitted with Westinghouse Alternate-current Motor.

long-span crane many useful jobs can be carried out along the front of the furnaces. Another point is that with the jib type of crane the piers for carrying the runway have to be in or about the middle of the moulding on the pig beds and are a source of trouble when casting, &c., whereas with the span crane the piers can be well clear of the pig beds. Where possible these cranes could be used for stocking the iron and loading out of stock again if room is available in line with the furnaces, and would certainly prove a great saving where this could be adopted. The lifting of the iron from stock can be undertaken by the modern powerful lifting electro-magnets suspended from the crane chain, which has proved to be a very satisfactory arrangement.

The metal after being run in the moulds and cooled is lifted by the crane and comprises the whole of one bed of iron of about 30 pigs with the sow attached; this is then taken to the pig-breaker, and in the case of hematite iron each pig is broken in two pieces and the sow broken into short pieces, the whole falling into a shoot and discharging direct into the railway wagons for delivery.

With regard to the handling of slag from the blast furnaces, very little has been done of late to improve the methods in general use. This is especially noticeable of the arrangements for delivering the slag to the slag tip or to the wharf for shipping to sea. Where it is necessary to deal with the slag in small pieces the method that appears to be the most successful is that employing the Hawdon's patent slag machine, which is a type of bucket conveyer and lends itself readily to electric driving.

The question of the respective merits of the two systems of motors, the direct type or the alternating two or three phase, will not be discussed here, but the author, having had a good deal of experience with both types, does not hesitate in recommending the alternating-current plant as being the more suitable for the rough work usually met with about ironworks, &c., and it will no doubt be generally admitted that the alternate-current motor is the more serviceable machine, even in the worst con-

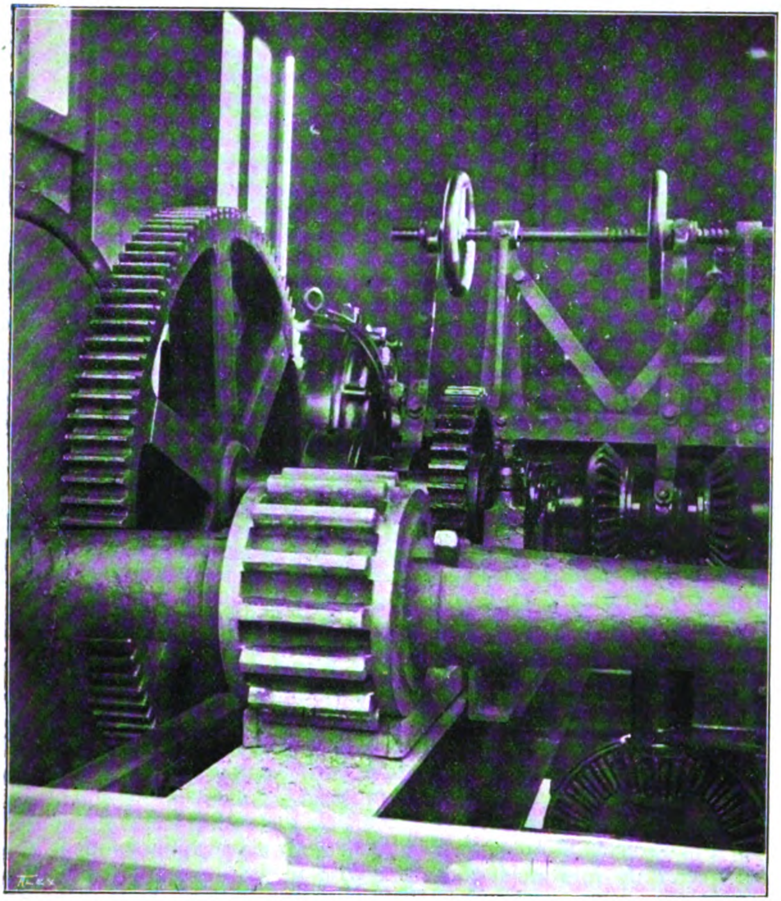


COKE-OVEN RAM DRIVEN BY WESTINGHOUSE THREE-PHASE ELECTRIC MOTOR.

ditions. When considering the question of motors for appliances where frequent stoppages are required, such as for cranes, &c., it is, however, necessary that great care must be taken when the alternating motor is adopted to see that those of the "slipping" type are adopted. They should have substantial variable resistances regulated by a good type of tramway controller, otherwise considerable breakdowns are likely to occur owing to the excessive current when starting up.

The practice now of building coke oven plants in close proximity to the blast furnace affords another opening for electric driving, if necessary the power being obtained either from the furnace gas or a combination of the furnace and coke oven gas supplies, as from coke ovens there is usually about one-third of the live gas, or gas other than burned under the ovens, available for power-generating purposes. This coke oven gas is very high in calorific value. Electric driving lends itself advantageously to these modern coking plants, and in many instances there are installations in constant use where very little attention is necessary to the arrangements of feeding, crushing and conveying the coal to the ovens, these being carried out automatically at a great saving in labour.

Starting with the coal as arriving at the works, this is usually tipped from a gantry into a storage hopper, from which it is fed into a disintegrator. Here it is ground into a very fine state and, passing through the disintegrator, falls into a boot to be then elevated to a large storage by an endless chain of buckets. With either type of motors for driving this sequence of machines, whether direct current or alternating-current, care should be taken to thoroughly protect them from the coal dust, and as this is most difficult to effect, it will be found that very much less trouble from the dust will be noticed with the alternating-current type of motor. The more compact arrangement obtains where each elevator is driven by its own motor, thereby saving the very heavy wear and tear on shafting and bevel drives, but it necessitates the proper relative speeds being attained in each elevator, *i.e.*, the elevator from the primary hopper to the disintegrator and the other from the disintegrator to the storage hopper, so as to preserve the automatic action of the plant and to prevent choking of the coal-crushing machines. In charging or filling the ovens with the coal

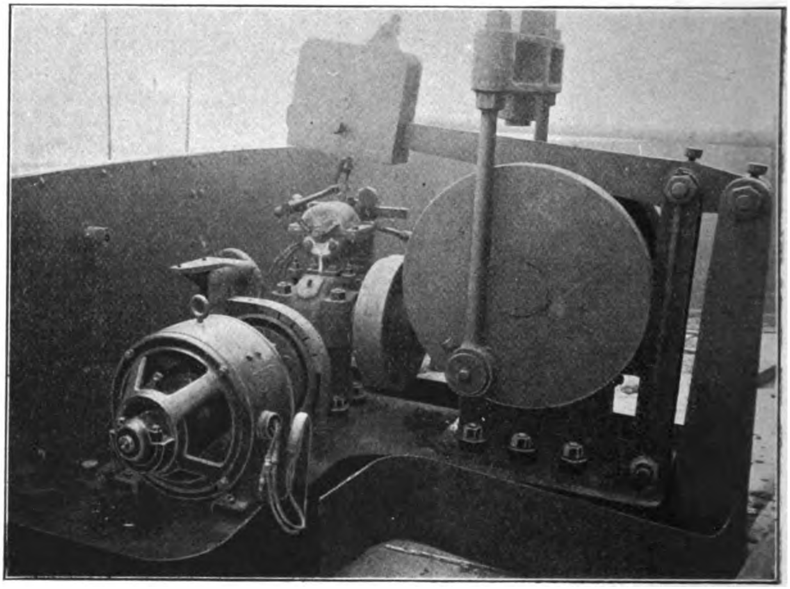


Interior of Cab of the Coke-oven Ram shown on page 246.

different systems are in vogue, some mechanical and some manual. The oven is usually charged on the top, through three holes spaced along the top of each oven, by tubs running on three lines of rails. These tubs have to be pushed along by manual labour, discharged into the oven, and then pushed back to the storage hopper for refilling. This system has been improved upon where top charging is necessary by using power-driven tubs or by using a hopper which runs along on the top of the ovens carrying a sufficient charge for filling one oven and usually electrically driven. Care has to be exercised not to put too much weight on the top of the ovens so as to interfere with the intricate brickwork of which these ovens are built, and in some instances the hopper supports are carried entirely from the ground, no weight being allowed to come directly on the ovens. This system should certainly show a saving on a fair-sized plant, not only economizing labour but also allowing the oven to be filled and closed up again in less time than by manual filling. Another form of charging by first compressing the coal in front of the ovens is in some cases adopted. This is done in a rectangular box of approximately the size of the coke oven, the bottom being in one piece and capable of carrying the coal in a block into the oven.

The coal is fed into this rectangular box by a movable shoot, which spreads the coal from end to end, this being then stamped solid. The two stampers are electrically driven, giving about fifty strokes per minute, the mechanical arrangement being remarkably ingenious. The sides of the box are then slightly eased, and the whole block run into the oven, the peal or bottom being then withdrawn. This system is very necessary with certain qualities of coal, especially the non-caking varieties. A very hard coke is produced by this method of oven-charging from a poorer quality of coal, and it has the further advantage of requiring very little labour for its operation.

After closing the oven the coal is coked in about twenty-four to thirty hours, when the oven is isolated from the gas mains and the ram is employed for pushing out the coke at the opposite side of the oven on to the coke bench, where it is cooled with water as it



Electric Winch for raising and lowering Furnace Bell.

emerges. The ram, which runs on a track parallel to the battery of ovens, is now generally electrically driven and consists of a carriage with suitable gear, whereby the ram with long, toothed rack is guided and driven through the oven, pushing the coke out before it in one solid block; the whole of the movements necessary can be carried out successfully with one motor of about 20h.p. In dealing with the coke on the bench there are various systems, a great deal depending upon the circumstances and position of the furnaces. At some works the coke is filled direct into barrows and taken to the blast furnaces either by wheeling or on an electric truck and is not again tipped until at the furnace top, when it is discharged into the hopper; this system certainly prevents the frequent tipping of the coke, thereby preserving its mechanical condition, which is important. Other systems are the using of a coke wagon capable of carrying the whole charge from one oven, which does away with the necessity of a coke bench, this wagon with the coke being hauled by electric motor to some suitable point for filling into ordinary coke barrows or discharging into a storage hopper, from which it is loaded into trucks. As already mentioned, constant tipping of the coke causes considerable depreciation in its value, and where possible it is probably most satisfactory to load it direct into coke barrows, although this may be a little more costly than the mechanical methods of filling.

There is also the question of driving the auxiliary plant in and about the coke oven plant, and in many instances electric driving can be economically carried out, especially for the pumps for circulating purpose. For driving the gas exhausters some doubt occurs with regard to the electric drive, firstly on account of the danger due to sparks from motor or switches, and secondly due to the low number of revolutions required for the exhauster, which would necessitate considerable gearing down of the motor speed.

In this article the author has endeavoured to point out briefly a few applications of the electric motor to iron works practice, in dealing with the mechanical moving and handling of material, and leaves for the present the interesting question of the manufacture or extraction of iron by electric methods.

◆

The Benardos Process of Electric Welding.

C. B. AUEL.

THERE are several distinct processes of electric welding in use at the present time, these being named, if not from the original investigators, at least from those who had most to do with demonstrating their feasibility; namely, Zerener, La Grange-Hoho, Thomson, and Benardos.

In the Zerener process, an arc is drawn between two carbon electrodes and caused to impinge by means of an electro-magnet upon the metal to be welded—this process is sometimes known as the electric blowpipe method.

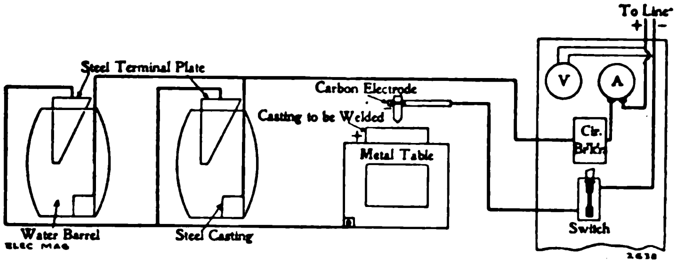


Fig. 1. Diagram of Electric Connections for Benardos Welding Process.

The process credited to La Grange-Hoho, otherwise called the "water pail forge," makes use of a wood tank filled with a suitable fluid into which is placed the positive terminal of an electric circuit. The metal to be forged or welded is connected to the negative terminal, dipped into the fluid and held there until a welding temperature has been reached. It is then removed and the forging or welding completed under a hammer in the usual manner.

In the Thomson or "incandescent" process, the metals to be welded are brought into intimate contact with each other, being held together by metallic, spring-actuated clamps, and in this position completing an electric circuit. The resistance at the point of contact between the metals is such as to produce a welding temperature in a very few seconds, when the two metals are then further forced together automatically, and welded in so doing.

In the Benardos process an arc is drawn directly between the metal to be welded, which forms one terminal of an electric circuit, and a carbon electrode, which forms the other terminal.

It is the purpose to describe here in detail this last-mentioned process and its application in connection with steel castings, pipes and plates, though it has a considerably wider range of usefulness.

The outfit required for the welding of steel castings includes a direct-current source of supply, a rheostat, a carbon electrode and fire-clay or carbon blocks for moulding purposes. An enclosure should be provided in which to carry on operations, for the glare from the arc is very intense and would seriously interfere with any other work in the immediate vicinity. The operator should have all parts of his body well covered (the clothing is quite sufficient), as even a few minutes' exposure to the rays will produce an irritating effect like sunburn upon the skin, resulting in a reddening and subsequent peeling of it, with, however, no more serious consequences. For the head a canvas hood is generally used, being fitted with a small window of coloured glass, through which the welding operation is watched without risk of injury to the eyes. The hands are usually protected by buckskin gloves provided with gauntlets to cover the wrists.

Current may be obtained from a 100-volt to 125-volt supply circuit or from an independently operated dynamo, or from a battery operated in conjunction with a dynamo or other supply circuit. An even higher voltage, say 220, may be used, but it is very wasteful of energy. Assuming that there will be sufficient welding to keep at least one man steadily employed, and taking into account the relative advantages and disadvantages of each of these several sources of supply, including first cost, subsequent maintenance, continuity of operation, simplicity and non-interference with other portions of the electrical plant, an independently driven dynamo is perhaps to be preferred.

It is of the utmost importance that the current supply be of ample capacity, for more failures may be traced to an inadequate supply than to any other cause. The dynamo should therefore be of about 75kw. to 100kw. capacity at 100 volts to 125 volts, shunt or compound-wound, belt driven or direct connected; if the latter, a flexible coupling must be used, otherwise armature burn-outs are likely to be of frequent occurrence. With the dynamo should be provided a small switchboard having mounted on it the necessary instruments, voltmeter, ammeter, circuit-breaker, field rheostat and switch. If the dynamo is driven by a motor instead of by an engine, one or two additional instruments will be required for the control of the motor.

The rheostat may be of the grid type, though a very satisfactory one is easily constructed by using two water-tight barrels placed side by side. The positive cable of the circuit is carried from the dynamo to the switchboard and from the switchboard to the water rheostat. At the rheostat this cable divides into two smaller ones, these being fastened to separate triangular steel plates not less than ¼in. thick, suspended above the barrels by means of pulleys and counterweights, so that the plates may be readily lowered into or withdrawn from the barrels as occasion requires the adjusting of the water resistance. Similar cables are run down the inside of each barrel and one end likewise fastened to a heavy plate of steel which lies on the bottom. The other end of each of these cables is attached to the casting to be welded or the cables may be fastened to a metal table and the casting simply laid upon it, always providing good contact is made. Discarded steel castings may be substituted for the steel plates in the bottom of the barrels. They should weigh about 20lb. or 30lb. each and not occupy too much room. The negative cable of the circuit is carried from the dynamo to the switchboard and from the switchboard to the vicinity of the casting to be welded, where it is provided with a metal terminal and clamp, into which the carbon electrode is tightly fitted. In order to manipulate the carbon electrode during welding, the negative terminal is held in a wood insulating handle, to which is attached a shield of asbestos or other fireproof insulating material. The exact form of the terminal and clamp, the insulating handle and shield, or the terminal plates of the water rheostat is immaterial, as is the method of attaching the cables to their respective terminals as long as good and sufficient contact is made, thus preventing undue heating at the joints.

The selection of the proper carbon requires some care, and while almost any kind may be used, such will not give the best results. The carbon is subjected to very hard usage, being alternately heated (frequently white hot) and cooled, this treatment having a tendency to cause it to crumble or flake and sometimes to crack in pieces. The flakes or pieces which happen to fall into the weld during the process are melted and mixed with the metal, thus producing a hard or high-carbon steel very difficult to machine. Experience seems to indicate as best for heavy work a hard, solid (not cored) carbon of 1in. or 1½in. in diameter, 6in. to 12in. in length, and one that, as it wears away, leaves a round stub end and not a long pencil point. For lighter work, a carbon of smaller diameter will suffice.

In the general repair of steel castings, iron rod of about ⅜in. diameter is used for filling, Norway iron is preferable, although small pellets from scrap boiler plates or steel castings may also be used, the choice between the rod and the pellets depending, to a certain extent, upon whether the weld is small or large.

The operator places himself directly in front of the casting, holding the negative terminal with its carbon electrode in one hand by means of the wood insulating handle, and having within reach of the other hand several pieces of iron rod. He then pulls the canvas cap well down over his head, as shown in Fig. 2, touches the carbon to the casting, thereby closing the circuit and thus producing an arc. As soon as the arc is struck, the carbon is withdrawn to a distance of 2in. or more (too short an arc will tend to produce a hard weld), and the arc allowed to play upon the casting until the metal commences to boil. It is advisable not to concentrate the arc on any one spot, but to give it a circular movement so as to heat the casting very thoroughly within the immediate vicinity of the proposed weld. This will tend to prevent too rapid cooling of the metal with its consequent chilling and hardening effect. The end of one of the iron rods is now placed directly in the midst of the boiling metal, where it gradually melts and mixes with it, the arc meanwhile being continued. As the rod melts away it is fed into the weld and this process is continued with one or more additional pieces of rod until the weld has been completed. The surface of the weld may be hammered as it cools off to produce a closer grain or to make it conform to some particular shape.

When pellets are used instead of the iron rod they are placed in the weld or cavity a few at a time and the arc applied, more pellets being added as the first batch is melted.

Should the part of the casting to be welded present a dirty appearance or contain slag, it should first be cleaned by means of a chisel or by the arc. In the latter case, this is accomplished by tilting the casting so as to allow the dirt or slag to drop off as fast as it melts when the arc is applied. After cleaning in this manner the casting is tilted back, and the welding then proceeded with.

If possible, the weld should be made with

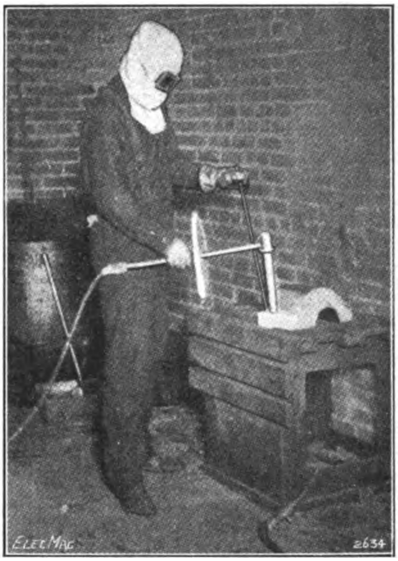


FIG. 2. THE PROCESS OF MAKING A WELD.

one continuous application of the arc without allowing the casting to cool off. The reason for this is that oxide of iron (scale) will form with each cooling, and if not removed will assist in producing a very hard weld, that is, one not easily machined. Where, however, it is not possible to make the weld with one application of the arc, the scale should be brushed off by means of a stiff wire brush. Hammering the weld after cooling will also very materially assist in this cleaning.

When instead of a cavity to be filled, it is necessary to build up a lug or to weld a piece to the casting, fire-clay or carbon blocks may be used for the purpose of confining the molten metal within certain desired limits or of having it assume a definite shape. The carbon blocks are generally worn-out dynamo and motor brushes, and while they can sometimes be used without further dressing, being built up around the space to be filled by the metal, they frequently require cutting to shape with a knife. When fire-clay is used it is formed to shape by the hand.

A large motor-frame casting is shown in Fig. 3. Upon removing the lower half of this casting from the sand, it was found that the strut which supports the axle lug had failed to pour, owing to the clogging of the mould with sand. A bar of wrought iron (1.5in. by 4in. by 14in.) was accordingly fitted into position and welded to the casting, as shown, the whole operation being performed by one man in about two and a half hours.

When the work is properly done, welds made by this method will give an average tensile strength equal to 70 or more per cent. of the original stock.

It would be exceedingly difficult, if not impossible, to set forth in exact terms the relations existing between current, size of weld, time required for weld, &c., on account of the different variables which enter in, but the following data, obtained in welding the spongy lug of a bearing-cap casting, is approximately correct, and will enable a rough idea to be formed of the magnitude of the several items involved. It must, however, be borne in mind that these figures represent average and not limiting values:

Line volts.	Amperes.	Volts across rheostat.	Volts across arc, including carbon.
126 (open circuit) ..	—	—	—
102	550	38	63
102	500	36	65
102	550	39	61
98	600	42	53
97	650	44	51
97	650	45	50
102	600	42	58

Time of weld = 56 seconds. Hole filled = 1¼in. diameter by 2in—approximately. Size of carbon = 1½in. by 6in.

Besides the welding of steel castings the Benardos process may be advantageously employed in many other ways. It will be found, for example, that surplus metal and sink heads can in many cases be removed from castings in much less than the time required when a cold saw is used, the arc not only doing the work quicker, but there being practically no time lost in setting the casting in position.—*The Electric Journal.*

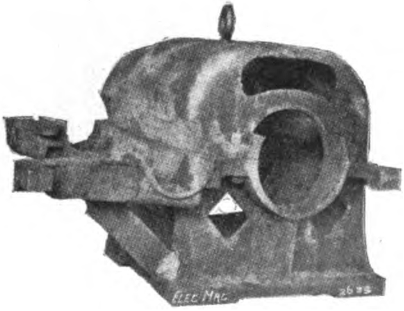


FIG. 3. EXAMPLE OF ELECTRIC WELDING.

THE GAS ENGINE AND ITS APPLICATION FOR ELECTRIC DRIVING AND OTHER PURPOSES IN IRON AND STEEL WORKS.

H. J. GIBBONS.

That electricity possesses many advantages for iron and steel works is shown by the rapid strides it has made during the last ten years, and it is doubtful if there are now any works of importance which have not their own central electric station for supplying light and power to the many branches and departments which together constitute a modern iron and steel works. In considering the installation of electric power, one of the first questions of importance is that of the prime mover. In the earlier works which were equipped with electric power this question did not often arise, as steam was practically the only prime mover available for such units of power as were required. The wonderful developments in the electrical industry have undoubtedly stimulated the demand for larger units, and have also placed within the reach of steam users a method of power subdivision and distribution which has given a further lease of life to steam power. Otherwise the gas engine would have been left without a rival where subdivision was necessary, owing to the ease with which distribution, combined with highest economy, could be carried out by means of gas mains. On the other hand, during the last decade electrical transmission has opened up new fields for the gas engine, which is already the primary power generator for electric cranes and tramways, and when the electrification of main railway lines takes place the last monopoly of the steam engine on land will be invaded. Although the internal combustion engine has expelled the steam engine from the smaller locomobiles, it is, of course, unlikely that it will be used for driving main-line locomotives of 1500h.p., but it is practically certain that the work of the latter will be done by electric motors receiving their supply from stationary engines and by means of electrical transmission.

The gas engine has advanced in efficiency and size until it threatens to displace the largest sizes of steam engines. With the introduction of the gas-producing plant, which can turn cheap coal or slack into a most suitable gas for driving engines, and with the application of waste gases from blast furnaces and coke ovens for direct use in the gas engine, gas power plants have been greatly developed, and can be obtained in sizes capable of supplying the largest amount of power that present-day requirements may demand.

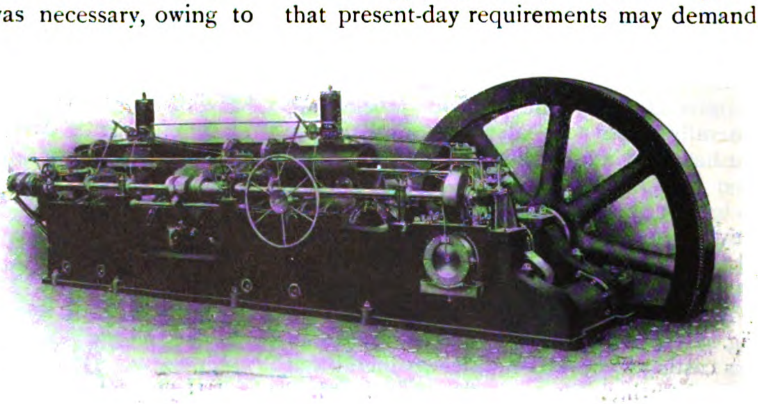
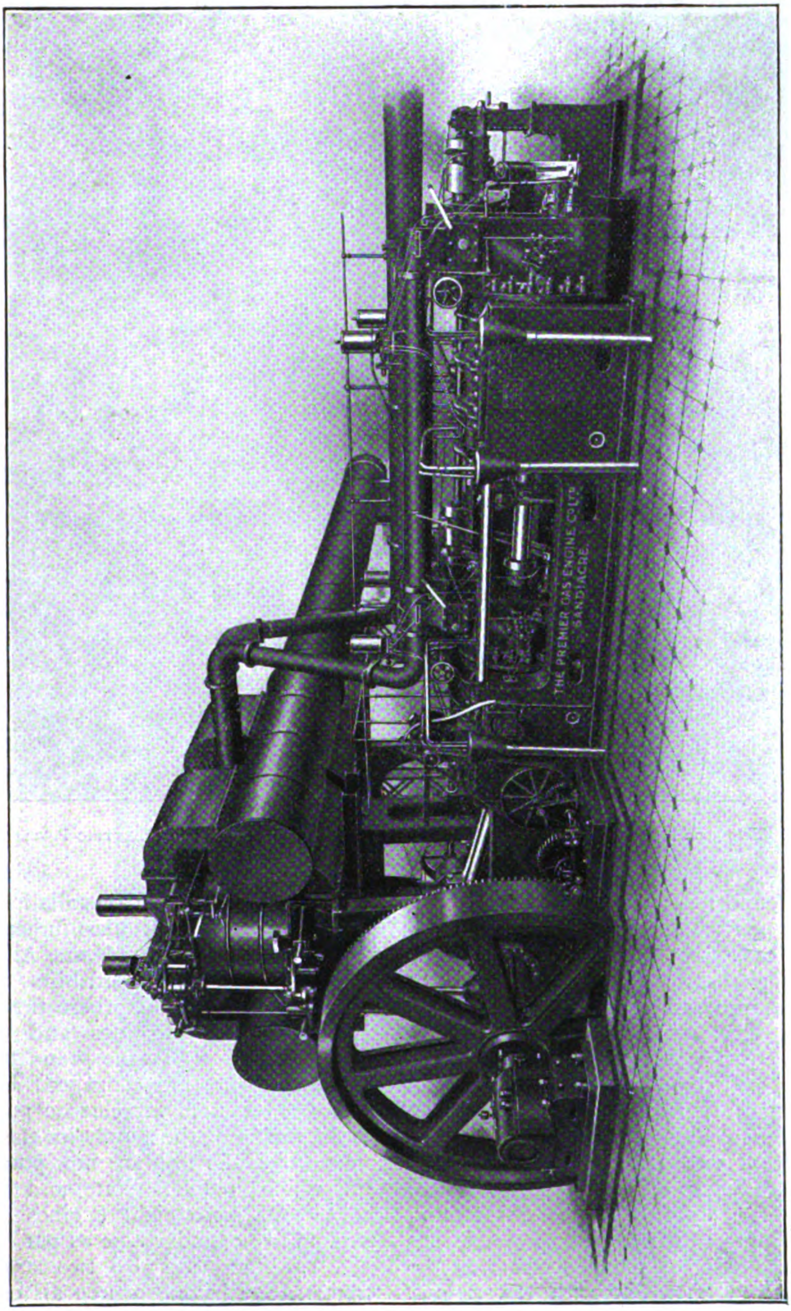


Fig. 1. Tandem Two-cylinder "Premier" Gas Engine, of which eight are working on Blast-furnace Gas driving Electric Generators at the Iron and Steel Works of Messrs. Alfred Hickman, Ltd., Bilston.



2. The 2000H.P. Blowing Engine working on Furnace Gas at the works of Messrs. Alfred Hickman, Ltd., Bilston.

The great fuel economy of the gas engine as compared with its rival has also been a factor in the enormous strides it has made, and although the gas power plant in conjunction with producers shows a marked economy when compared with the most up-to-date steam plant, furnished with all the complex aids which are necessary to secure the best results in economy, the gas engine obviously offers still greater advantages when a gas

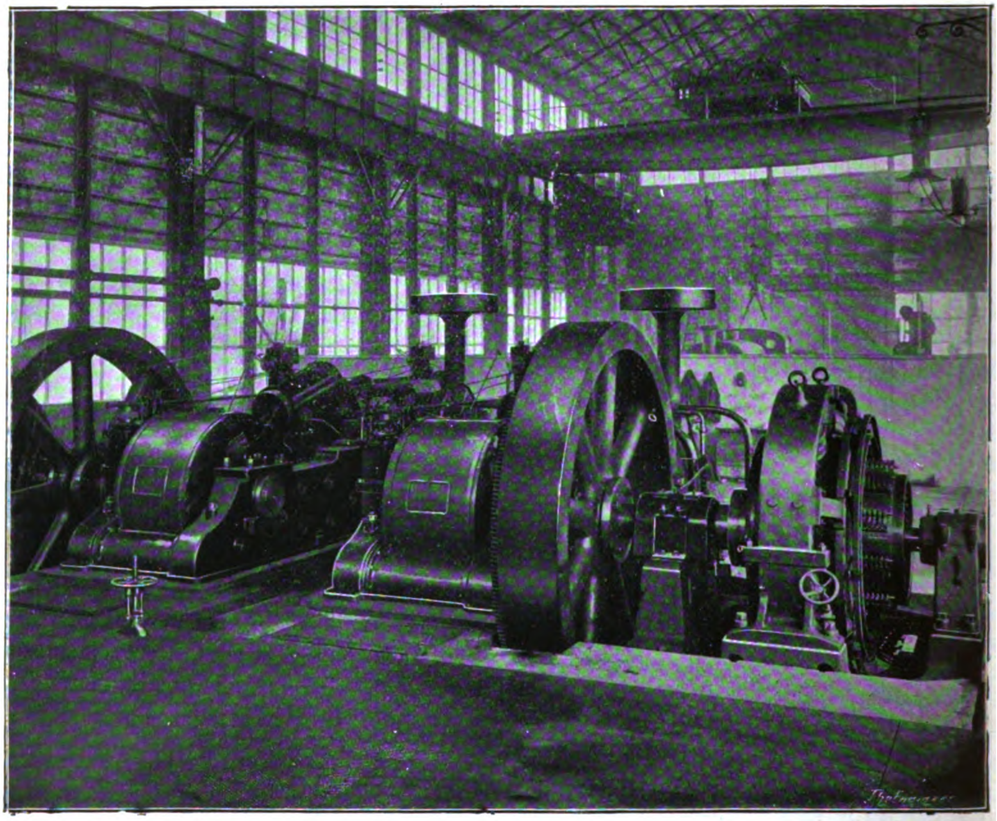


FIG. 3. TWO 500H.P. GAS ENGINES SUPPLIED FROM COKE-OVEN GAS AND DRIVING ELECTRIC POWER PLANT AT THE CARGO FLEET IRON COMPANY'S WORKS.

supply is found ready made and of a quality which can be used direct in the gas engine, as is the case with blast-furnace and with coke-oven gas.

In many iron and steel works, boilers are fired with blast-furnace gas for supplying steam to engines, but on an average not more than 8.25 per cent. of the heat in the gas is turned into useful work, whereas the gas engine would utilize 30 per cent. Indeed, from experience obtained on the Continent, efficient steam engines supplied from gas-fired boilers show a consumption of from four to five times as much gas for the production of a given power at the engine shaft as compared with gas engines, and as the bulk of existing steam engines in iron and steel works are not generally efficient, it may be assumed that the economy in gas effected by changing from steam engines to gas engines will in the majority of cases be 9 to 1 in favour of the gas engine.

One of the largest installations of gas engines working on blast-furnace gas in this country is that of Messrs. Alfred Hickman, Ltd., the Staffordshire Steel and Ingot Works, Bilston, where there are ten large "Premier" engines and several of other makes. Of the ten "Premier" engines, eight are engaged in driving dynamos for supplying electric power to the works, including the supply for the new steel plant which the firm are now putting down, and which includes plate and bar rolling mills. All these eight engines are of the tandem two-cylinder type as per illustration Fig. 1. There are also two large blowing engines, one having a free air capacity of 40,000 cubic feet and the other 18,000 cubic feet per minute. An illustration of the former, which is perhaps the largest blowing engine in Great Britain at the present time, is shown in Fig. 2.

Among other installations of gas engines using blast-furnace gas for electric and other purposes may be mentioned those at Frodingham, Cargo Fleet, and Cochrane & Co., Ltd. (Middlesbrough).

In a few iron and steel works coke-oven gas is used for generating electric power, and an illustration is given in Fig. 3 of two 500h.p. "Premier" engines which have been running at the works of the Cargo Fleet Iron Co., Ltd., Middlesbrough, for some years. These engines are direct-coupled to generators. Owing to its high calorific value, there is always great liability to pre-ignition on engines using coke-oven gas. The Positive Scavenger Arrangement which is a feature of the "Premier" engine, however, prevents pre-ignition.

Many instances are to be found where gas engines are working in iron and steel works running on producer gas made from bituminous slack, the gas being used for heating and furnace work in addition to its application in gas engines.

The Farnley Iron Co., Ltd., near Leeds, have one 650h p. tandem and two 250h.p. single-cylinder "Premier" engines all direct-coupled to dynamos. In this case the gas is supplied from a "Mond" producer.

Messrs. Cochrane & Co., Ltd., of Dudley, have two 250h.p. single-cylinder "Premier" engines direct-coupled to dynamos, and two 150h.p. of the same type for driving their shops; they also have a gas-driven blowing engine, of which an illustration is given in Fig. 4. All these are working on gas produced from a "Mond" plant.

Another important installation of "Premier" engines is that of Bayliss, Jones, & Bayliss, Ltd., of Wolverhampton, where there are one 650h.p. tandem, one 150h.p. and four 250h.p. single-cylinder engines all direct-coupled to dynamos. These supply power to the many departments of the firm's works, including rolling mills.

A large steel works in Sheffield has also recently installed two 500h.p. "Premier" engines in their power station. These engines are fed from producer gas supplying the steel furnaces. This installation is shown in Fig. 5.

Another application of "Premier" gas engines is that of Messrs. Monks, Hall, & Co., Ltd., Warrington, where a 650h.p. tandem engine drives a train of rolls by direct-coupling to the engine shaft, and another train by ropes from the flywheel.

One of the objections urged against the gas engine is its alleged want of reliability, but the running of some of the engines above-mentioned proves that this objection exists no longer. The engines at Messrs. Hickman's have run for several weeks at a stretch without stopping, and are seldom used for less than a fortnight's continuous run at a time. The large blowing engine is in continuous service except a stop of a few hours once a fortnight for cleaning.

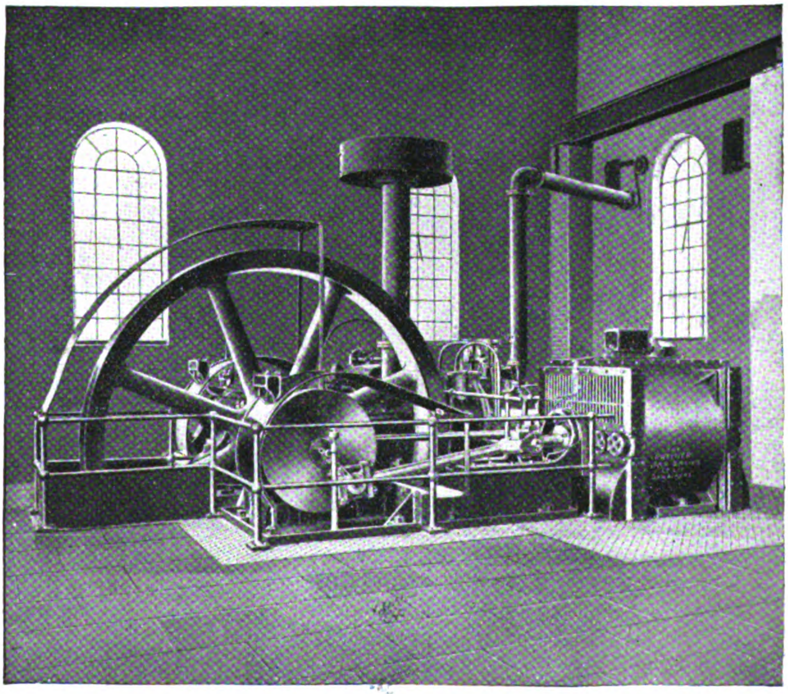


FIG 4. SINGLE-CYLINDER GAS ENGINE DRIVING BLOWER AT THE WORKS OF MESSRS. COCHRANE & CO., LTD., DUDLEY.

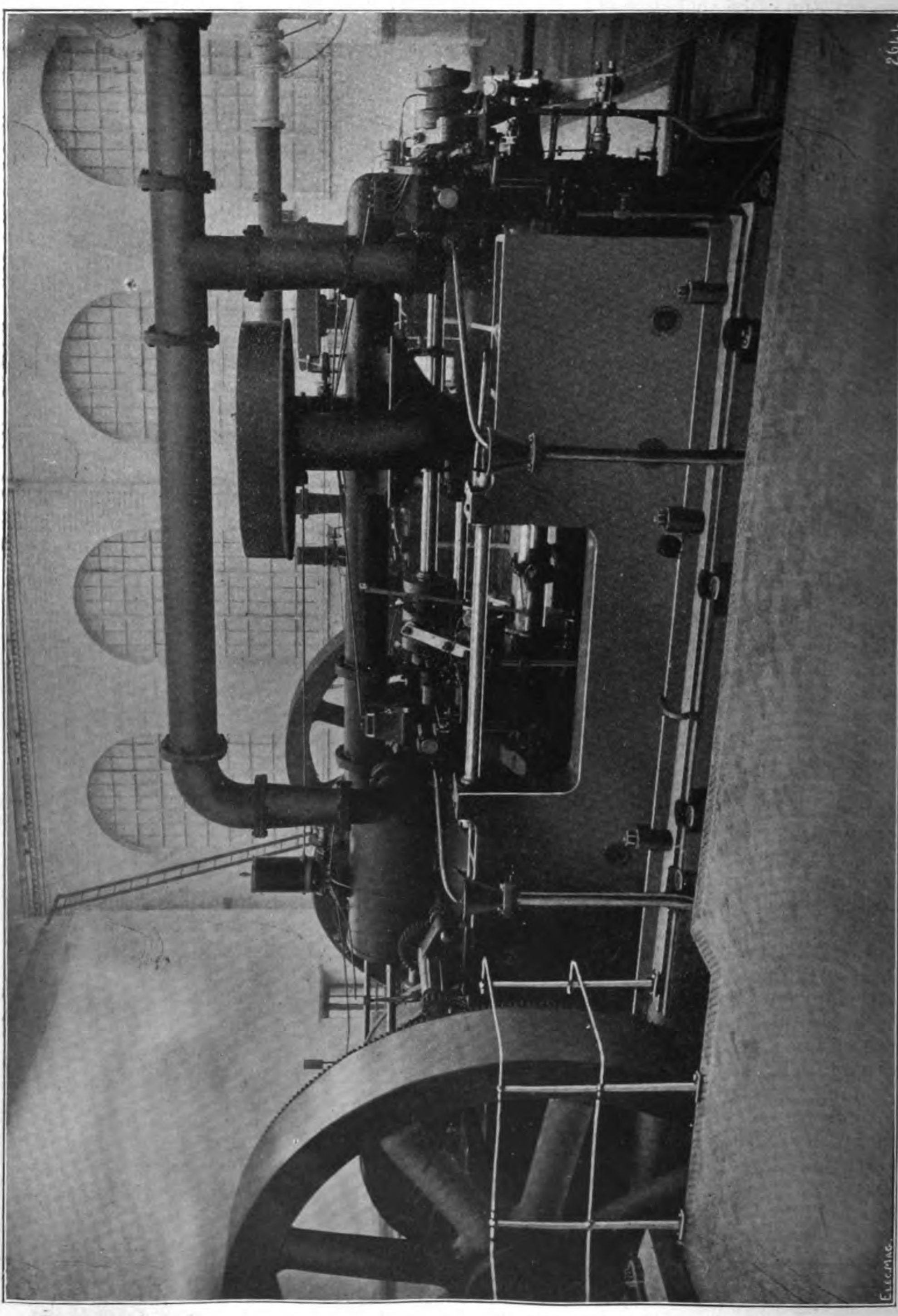


FIG. 5. TWO 500H.P. PREMIER GAS ENGINES IN THE ELECTRIC POWER STATION AT A LEADING SHEFFIELD STEEL WORKS.

Another of the large engines referred to frequently makes runs of four to six weeks' duration without a stoppage of any kind.

For iron and steel makers who have blast-furnace gas available there is the abiding fact that the gas engine will consume their gas direct, and for a given amount of gas will furnish many times as much energy as by any other means of using the supply. Moreover, the complete adoption of the gas engine as the prime mover in the power system of their works will probably furnish all the increasing power which the newer systems of working demand, and render it unnecessary to consume fuel anywhere except in the blast furnace.

* * *

ROPE DRIVING.

THOMAS HART.

ROPE driving is generally met with under different conditions when applied to the coal, iron, steel and kindred trades than when met with in the textile industry. Probably 85 per cent. of the Lancashire cotton mills are driven by ropes from the flywheel of the engine direct to the main shaft in each different storey of the mill. It would be difficult to find anything more efficient and yet more economical than this system of main driving for a textile mill. Whilst the general conditions of the majority of engineering works do not lend themselves to the same large scale of rope driving as they do in a

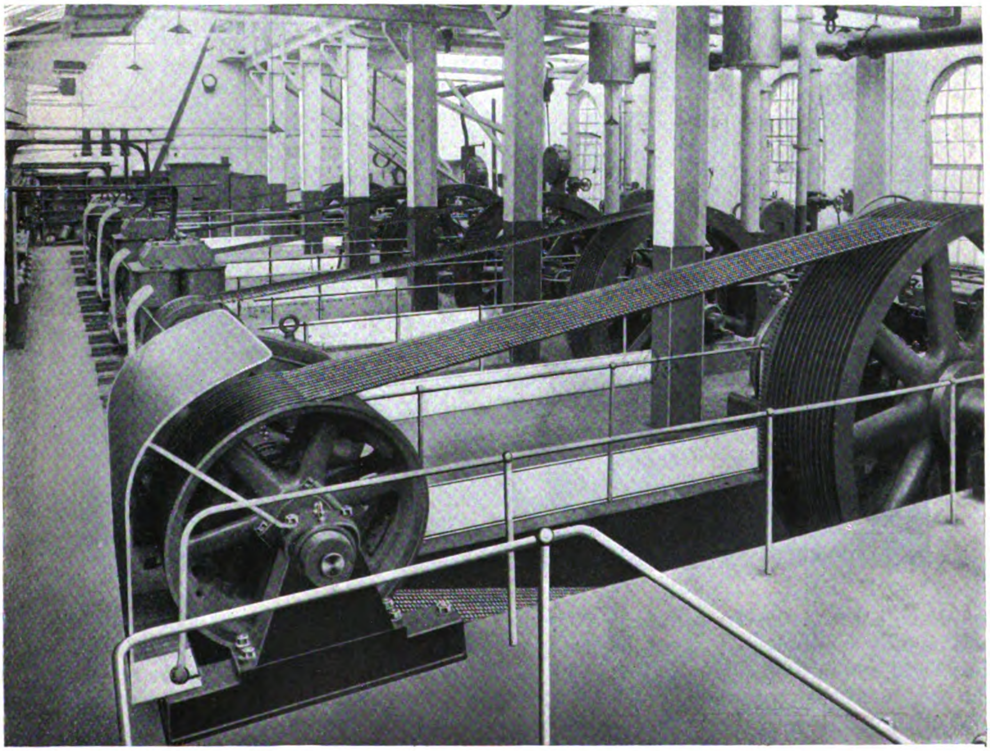


FIG 1. VIEW OF POWER HOUSE CONTAINING SIX "PREMIER" GAS ENGINES DRIVING GENERATORS. EACH DRIVE CONSISTS OF THIRTEEN "LAMBETH" ROPES 1⅜IN. DIAMETER.

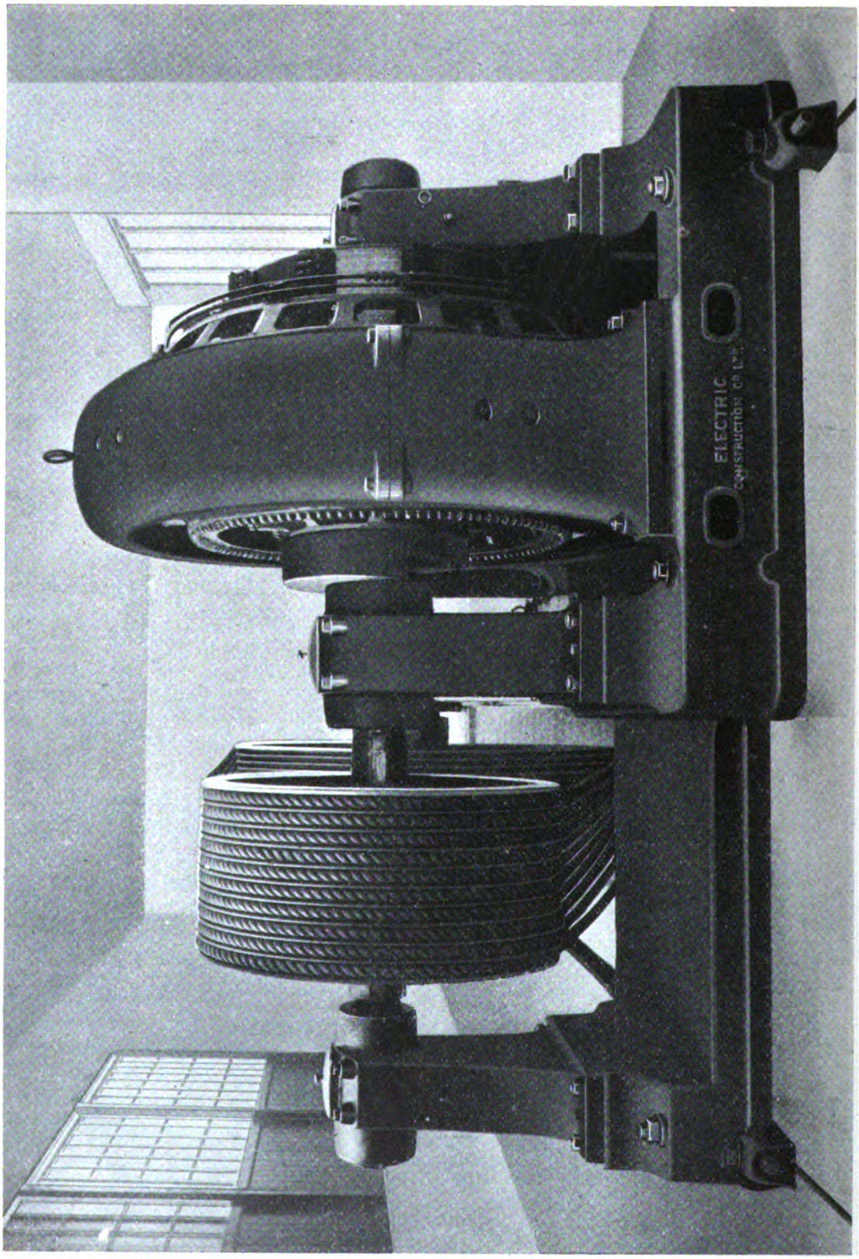
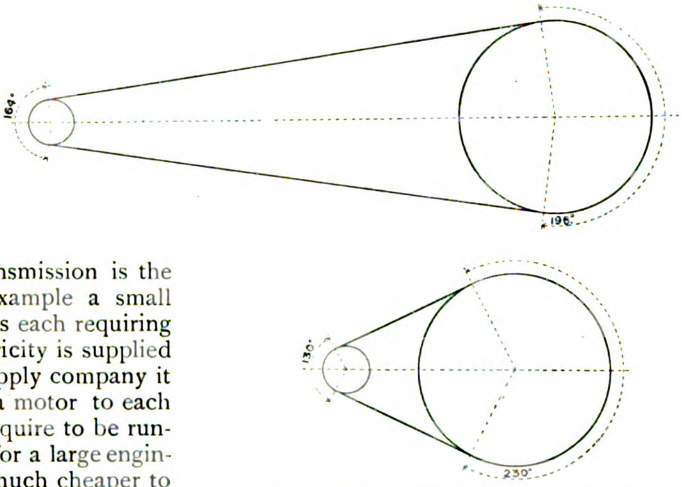


Fig. 2. A 600 h.p. Motor, driving Rolling Mill by means of Ten Ropes 2in. diameter.

textile mill, yet the *system* is equally efficient and equally economical. There is to-day a very large amount of rope driving amongst the engineering shops and foundries of this and other countries. Where power is generated by a prime mover, whether that prime mover be one of the many types of steam engine, gas engine, or steam turbine—and that power has to be transmitted to a line of shafting revolving at the same speed of may be at a speed widely different—rope driving in almost every case offers the most economical and efficient means of transmitting the power.



Figs. 3 and 4. Showing difference in Arc of Contact between Drives of different Lengths, when the Pulleys are not of Equal Diameter.

Engineering works are often put forward as presenting a great opportunity for the adoption of electrical transmission of power. It is not the object of the present article to institute a comparison; there are cases where on account of the conditions or special circumstances, electrical transmission is the best to adopt. Take for example a small shop having several machines each requiring from 1h.p. to 5h.p. If electricity is supplied by Corporation or public supply company it might be cheapest to have a motor to each machine, as all would not require to be running at the same time; but for a large engineering works it is probably much cheaper to have a large steam or gas engine and drive direct from the flywheel by means of ropes. There are, however, very many cases where a combination of the two systems presents the most efficient means of driving. Fig. 1 shows a set of dynamos in an engineering works driven by ropes from gas engines. Fig. 2 shows a rope drive from a motor in a rolling mill. In collieries this type of drive has been very extensively adopted: the power is generated at the surface, taken down the pit in cables, and given out by motors, through ropes to pumps, haulage plants, fans, &c. Rope driving to be successful requires care in design, and the writer hopes that the following notes will be of interest and service.

In considering the number and thickness

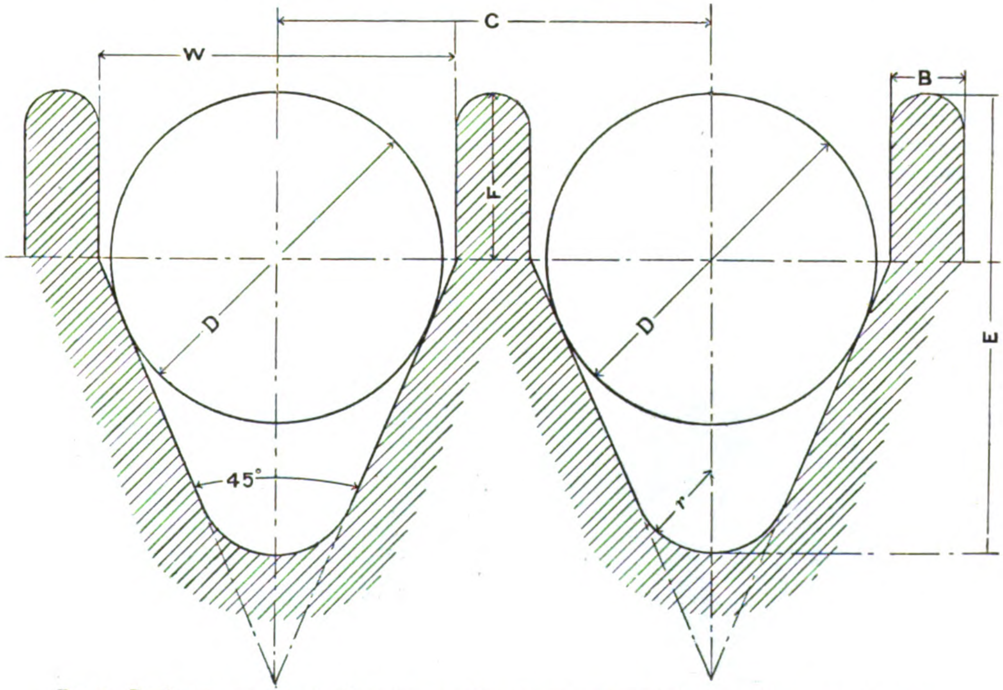


Fig. 5. D = Diameter of Rope. B = 0.2D + 0.05. C = 1.2D + 0.2. E = 1.4D. F = 0.5D. W = D + 0.15. r = .25D.

of ropes for an installation, the sizes of pulleys that can be used (and these in turn depend upon the speed) require to be taken into consideration. A very safe rule is to have no pulley less than thirty times the diameter of the rope, though in connection with electrical installations this rule is often broken, and ropes 1¼in. diameter are frequently set to work on pulleys 1ft. 6in. to 2ft. diameter. With the smaller sizes of ropes, say from 1in. to 1⅜in. diameter, the rule need not be so strongly enforced, but with the thicker sizes of ropes it is a very important matter.

The horse-power that ropes will transmit depends very greatly upon the speed, as will be seen from the following table: a small working margin should always be allowed on this table, and if there are any unfavourable circumstances in the drive then this margin should be more liberal.

TABLE OF HORSE-POWER ROPES WILL TRANSMIT.

Diameter of Rope:—	in. 1	in. 1⅛	in. 1¼	in. 1⅜	in. 1½	in. 1⅝	in. 1¾	in. 1⅞	in 2
Speed in feet per min.									
1000 ...	4	5	7	8	10	12	14	16	18
2000 ...	9	11	14	17	20	24	28	32	36
3000 ...	12	16	19	23	28	33	38	44	50
4000 ...	14	18	23	28	33	39	45	52	59
5000 ...	15	19	24	29	34	40	46	53	60

No advantage is gained as far as the power transmitted is concerned by going above this speed. The strain on the ropes at stopping and starting is also more severe, and owing to the action of centrifugal force, the power the ropes will transmit is reduced rather than increased at speeds above 5000ft. per minute.

The arc of contact of the ropes with the pulleys should be taken into consideration. In electrical installations there are greater variations of speed between driver and driven pulleys than with any other class of work. A dynamo running very quickly has often to be driven from a slow-running shaft, or a slow-running shaft has often to be driven from a quickly running motor, in either case involving considerable variation in pulley diameters. The theoretical arc of contact of the ropes with the pulley when both pulleys are of equal diameter is 180deg. Figs. 3 and 4 show the arc of contact with the small pulley, assuming the pulleys to bear a ratio to each other of four to one. In such cases the load on the ropes should be lighter than when the pulleys are more approximately equal.

It will also be seen from these figures that the length of drive has an important bearing on the arc of contact in such drives as those now being considered. This is generally decided by convenience, but the point is worthy of consideration in designing a rope drive. It is not uncommon to find drives in cotton-spinning mills of from 60ft. to 95ft. centres. The pulleys are generally large in diameter (say 30ft. diameter on to a 6ft. 6in. diameter) and the drive at an angle of about 45deg. These drives work exceedingly well, but it would not be wise to arrange an horizontal drive with both pulleys, say 3ft. diameter at 95ft. centres, on account of the sag of the rope.

In considering the shortest drive it is advisable to use it is necessary to bear in mind that the shorter the drive the greater the amount of bending the rope has to undergo, and it is the bending, perhaps more than anything else, which wears out a rope. Supposing a drive with a pulley 2ft. diameter driving a 5ft. diameter at 10ft. centres. If the motive power was a motor, the speed of the 2ft. pulley might be 700r.p.m.; this would give a rope speed of 4375ft. per minute, and the rope would make approximately 140 circuits of the drive each minute—a very large amount of bending. Such a drive would undoubtedly be severe on the ropes, but it is not an im-

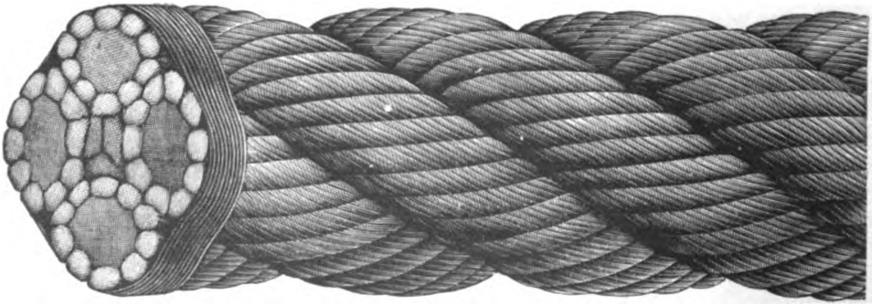


Fig. 6. Four-strand Lambeth Driving Rope.

possible arrangement. These illustrations will serve to show the elasticity and the possibilities of the rope-transmission system.

The shape of groove also is an important factor: the sketch Fig. 5 shows the shape of groove now almost generally adopted as a standard. There are many good grooves varying slightly in form and shape from this, but the object of the writer has been to show a groove that represented as near as possible what may be termed the general practice. The sketch shows a groove designed for ropes 1¾in. diameter. By following the proportions given, the measurements of the different parts for any other size of rope can be readily obtained. Grooves for carrier pulleys are generally made **U** shape.

Rope driving, carefully designed and erected, is probably less troublesome than any other drive. It is important to have the pulleys large enough; it is important not to overload the ropes; it is perhaps most important of all to have a good driving rope.

The "Lambeth" ropes (made by Thomas Hart, Blackburn), are specially designed for power transmission—every feature of excellence suggested by the experience of a quarter of a century being embodied in these ropes. The illustration Fig. 6 shows the four-strand rope, but it is also made three-strand for those who may have a preference for a three-strand driving rope.

THE DRIVING OF MODERN ROLLING MILLS.

GERALD J. HOOGHWINKEL, M.Inst.E.E., M.Inst.M.E.
Consulting Engineer.

(*The following is a reprint of the valuable paper read before the Sheffield Society of Engineers and Metallurgists on January 27th of this year and which has been revised and modified by the author for the purpose of this publication.* Ed. E. M.)

* * *

ALTHOUGH this paper has been written with a special view to the application of electricity, the writer has taken the opportunity to briefly describe and discuss the other agents which are being employed, viz., gas and steam directly applied. In order to avoid repetitions and to condense the paper as much as possible, only three-high mills and reversing mills of the heaviest type will be dealt with. All the smaller mills, such as small finishing mills, continuous rod-mills, &c., can be better and more cheaply driven by electric motors, in most cases without an additional equalizer set, such as the Ilgner, Westinghouse, or other systems.

The final economy, especially when taking into account the amortization of the initial capital outlay of driving heavy three-high and reversing mills by electricity, has not yet been universally accepted by steel works engineers, and must first be tested in actual practice. At least six electrically driven reversing mills of the heaviest type with motors up to 10,000h.p. each are now at work, and the writer proposes to deal with the results of these mills at the end of this present paper. The question of final economy is a very complicated one, and the case is not quite so clear as in an analogous case, viz., the electric-driven winding engine, which has been treated by the writer in former papers.

The main difference is more quantitative than qualitative, because in the case of the rolling mill the stored energy of the system cannot be utilized for starting again. The flywheel masses of rolling mills and the radius of gyration are small, and there is no question of direct electric braking, giving energy back into the system, but the mill comes to a stand-still almost immediately the current supply is cut off. Notwithstanding these differences, however, the writer hopes in the following lines to prove that the advantages and savings to be derived from the centralization of the power required in modern steel works are such that the large capital outlay is not only fully justified by the ease of driving the mills, but also by the actual savings in fuel and wages.

Heavy Three-High Mills.

Direct-Driving Steam Engines.

In this country there exists a marked preference for the steam engine, which is only natural, but which also explains the slow progress of the large electric motor and the large gas engine for heavy drives in collieries and steel works. The advantages of the steam engine are, briefly: the possibility of exercising a powerful and momentary effort when required by the mill by varying the cut-off; the possibility of varying the speed at any time and at once, thereby enabling the fly-wheel to store and give back energy. This flexibility is of great value, but is offset by the heavy steam consumption and wear-and-tear on the engine, more wages and more room (boilers), and unequal torque. Only the first of these drawbacks is capable of reduction, the others rather tending to increase with more powerful mills.

The steam consumption of a three-high mill is even greater than that of a reversing mill, on account of the long periods during which the mill runs light. Compound condensing engines and low-pressure exhaust turbines are among the means adopted to reduce the steam consumption.

In order to show the results obtained by the central condensation, it will be sufficient to cite a recent test carried out on a modern twin-condensing mill engine of 1200h.p., by means of a number of belt brakes on all the revolving parts of the mill. The result was 15lb. of steam per i.h.p. hour, with a steam pressure of 120lb. and 50deg. F. superheat. This represents about 18lb. per useful h.p. hour. A later engine of the same type showed an even better consumption of 13lb. per useful h.p. hour. The average steam consumption with engines of this type and output, but non-condensing, is about 25lb. to 40lb. The figures given above do not include, however, the steam consumption of the pumps, &c., of the central condensing plant, and are only—and this is the crucial point in comparison with electric driving—applicable during the actual rolling process. Taken per 24 hours or per year, they are more than double. The rolling period is much shorter than is generally expected; it is as a rule not more than 8 to 10 per cent. of the time the rolls are running. The yearly load factor is even less and not more than 5 per cent.

In the case of a 1200h.p. South German mill, a 500kw. exhaust turbine was driven from the mill engine. The plant which this exhaust turbo-dynamo displaced would have required about 18lb. of steam per unit, or about 9000lb. per hour. The steam consumption of this particular mill engine was 40lb. per h.p. per hour, so the reduction was equivalent to 25 per cent.

The saving in capital outlay, however, is not so great, and while a central condensing plant can be put down at a moderate cost, the turbo-dynamo with high-vacuum condenser, accumulator, &c., requires a far heavier outlay, and it is in the writer's opinion more or less questionable whether a single central condensing plant giving a vacuum of about 25in. to 26in. is not a more economical arrangement in every respect. Moreover it destroys the idea of centralization and creates a separate power station with separate attendants, and although not requiring live steam, the running costs will not be much less than the same plant capacity, forming part of a large steam or gas-driven power station with large units. There are, however, many cases where *existing* mill steam plant could be improved, especially in smaller works with only one or two heavy mills where all the other plant could be driven by the power derived from the exhaust turbine, and where there is no other electric power station.

The saving to be effected in running such plant as shears, rolls, cranes, and other auxiliaries by electricity will in such a case provide an offset against the heavy capital outlay and running cost of the exhaust turbine plant. For large new works—and this is the question under discussion at present—the writer holds that the exhaust turbine plant has no place.

Direct-Driving Gas Engines.

Although the direct drive by means of powerful gas engines is quite the latest addition to rolling mill practice, and has not yet outgrown the troubles always met with in new adaptations of even older power generators, the writer proposes to deal briefly with this drive on account of its resemblance to steam drive.

The first gas engines used for driving rolling mills were invariably too small. It is well known that the term "maximum output" with the gas engine means at the same time the output which can be maintained continuously with the most economical mixture of gas and air and such variations in the quality of the gases as are likely to occur. The gas engine required to produce the same maximum effort as the steam engine has to be about 50 to 80 per cent. larger. In order to fix the continuous maximum output, the best method is to base the calculation on the mean pressure in the gas cylinder and to take this pressure fairly low, say, about 60lb. per square inch. If sufficiently large, the gas engine will perform the duty of running the mill as satisfactorily as the steam engine. It also possesses the advantages of direct and positive effort when required and easy and momentary change of speed to utilize the flywheel capacity. Fundamental changes of speed (required for rolling different materials) can be obtained, as with the steam engine, by variation of the regulation. The room occupied is about the same, the labour required is not less; although no stokers are required, on the other hand the gas-cleaning apparatus requires a certain amount of labour. The first cost of engine, pipe line and cleaning plant is about 50 per cent. more than the cost of steam engine and boilers. The gas engine also produces the same irregular torque as the steam engine. Both systems have also the advantage that their variations in power do not disturb the main source of power to any extent.

With regard to the running costs, it has been the writer's experience that, in comparison with gas-fired boilers and steam engines, the costs are fairly equal if one includes interest and depreciation, wages and oil, and if the value of the gas be taken as equal to ¼d. per 1000 cubic feet, as has been proposed in this country. This value, however, is decidedly too low. The price of coal at steel works is as a rule not low, and at the present time 10s. to 12s. per ton may be taken as an average in this country. On this basis, the commercial value of the gases is about ¾d. per 1000 cubic feet, and in comparison with coal-fired boilers, the fuel costs of the gas engine drive are less than those of the steam drive. An example from actual practice will easily show this. In a South German steel works, the same type of mill as was described when dealing with the direct steam drive (requiring a 1200h.p. steam engine) is driven by a 2200h.p. twin gas engine using 120,000 cubic feet of gas per hour, or about 8s. against two tons of coal costing 20s. This difference, however, is reduced by the consideration of interest and depreciation, repairs and maintenance, loss of time through cleaning, &c. It is in the latter point that the gas engine is distinctly behind the steam engine, notwithstanding the recent advances in construction.

The gas engine used for mill driving has not only to withstand the enormous

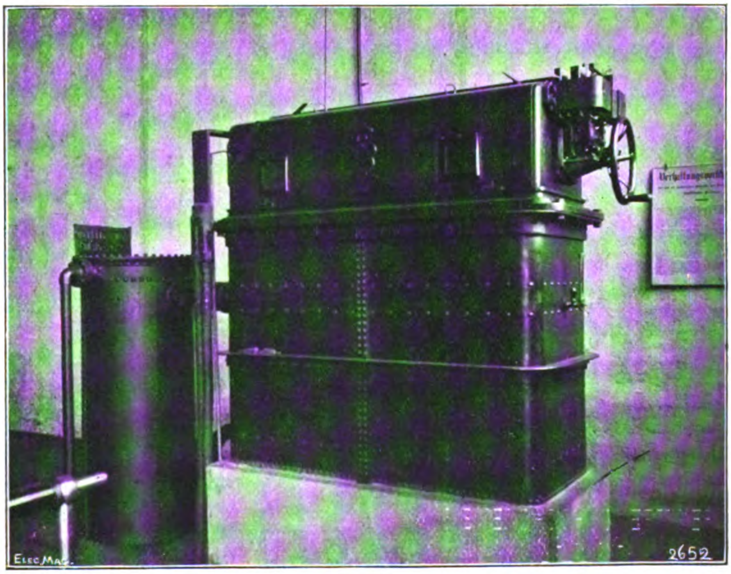


Fig. 1. Liquid Starter for Direct Current Rolling Mill Motor.

outward stresses and variation of the drive, but also the very heavy inward stresses due to high temperature and pressure, and also those due to miss-fires and back-firing. Besides, the periodical interior cleanings and inspections entail a certain amount of loss in working time, and expenditure in wages. Most of the troubles in gas engines, however, can be traced to the state of the cooling water, so that it is often required to use cooling towers.

If the blast furnaces are a long way from the steel works, the long pipe lines and compressors will be found to become a serious item, also as far as reliability is concerned.

For small mills, the direct drive by means of gas engines has no advantages whatever, and for the larger fly-wheel mills it will always require careful consideration whether the economy in fuel or gas consumption is balanced by heavier capital costs and unreliability.

The variable composition of the gases is another drawback which can be met with by the use of a gasometer and a very liberal calculation of the gas engine.

Up to the present the direct gas-engine drive has not been a success, although, as already explained, the reasons are now well known, and can for the greater part be provided for. For light steel mills, as at the Köningshof steel works, two 1200h.p. Nurnberg engines have given entire satisfaction, each driving two trains. In any case twin engines should be used so as to be able to work one side and drive the mill with half the output if repairs and cleaning are required on one of the units. It much depends, of course, on the number and output of the various mills and the auxiliary plant, the system of rolling, the variation in materials, the proximity of the furnaces, the capacity of the electric generating station; but the writer is inclined to use electricity throughout, using gas-fired boilers if sufficient gases are available, and if not, to drive all the smaller mills by electricity generated by means of gas engines, and the one large mill by steam. This again depends on the power required by the one large mill in comparison with the generating station.

Electric Driving.

In order to facilitate the comparison, it may be well to first of all enumerate the advantages claimed by the electrician, and the disadvantages claimed by the other side, and to see whether these hold good in actual practice. Some of them may be accepted without further proof, having regard to the results obtained in other industrial applications.

ADVANTAGES.	DISADVANTAGES.
1. Constant and regular torque.	1. Less efficient, and wasteful speed regulation.
2. More reliable, less breakages of couplings, pinions, &c.	2. Influence of the variations of the required power on generating station.
3. Less room, on account of absence of boilers, pipes, &c.	3. Electric motors overload themselves until circuit breaks.
4. Easy adaptation to mill.	4. Higher fuel costs than direct gas-engine drive.
5. Easy and simple handling.	5. High capital outlay.
6. Easy distribution by means of electric cables, instead of steam pipes or gas pipes.	
7. Advantages of centralizing the power.	
8. Less labour.	
9. Lower fuel costs.	
10. Less oil and other stores.	
11. Use of gas engines of medium size in power station.	
12. Increased output due to higher speeds.	

A further advantage is the power control and checking, which is easily effected by means of the usual electrical instruments at any moment. This advantage, although at first sight of not much value, has proved to be of great benefit with haulage installations in collieries, where it shows at once when a haulage road becomes bad. Savings of from 30 to 40 per cent. in power have resulted from prompt repairs of these defects, which remain hidden with steam haulages. The same applies to rolling-mill gear, pinions, housings, &c.

The writer proposes to deal only with the advantages under items 7, 8, and 9, and in passing touch upon the advantages claimed under items 4 and 5. The other advantages having been proved so often in other and similar installations of electric driving, may be taken on trust.

Of the disadvantages, item 1 will be dealt with at the same time as item 9, and the others being of less importance or, like items

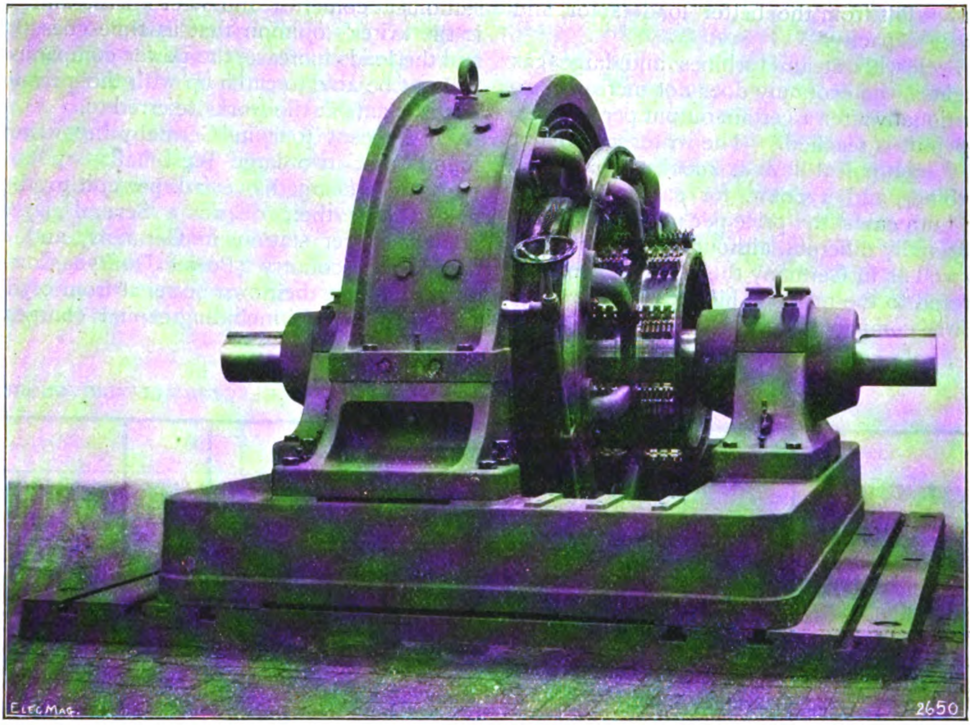


Fig. 2. Direct Current Rolling Mill Motor, 800h.p. normal, 1,600h.p. maximum, 330-260r.p.m.

2 and 3, easily counteracted, will be left for the time being, the main question under discussion being item 5.

Up to the present, only continuous-running mills of the three-high type have been under discussion. Any savings and advantages which may be proved in this case will apply also to reversing mills and with greater effect, just in the same way as electric winding and haulage represents the largest saving in fuel in a colliery, as against pumps and fans.

This is a point which is not yet thoroughly grasped, and the main point still under discussion in this country is the capital outlay.

Electricity scores with the intermittent drives, the continuous drives contributing to the savings by the greater number of units required per year, thereby increasing the yearly load factor. The intermittent drives provide savings at the motor end, and continuous drives at the power station end—to put the whole question in a nutshell.

The power supply should be kept separate, and the generating costs per unit, which must include all capital charges inherent to the power plant, will be used to get at the cost of running electrically-driven mills. This does away with the question, so difficult to apply correctly, of how much of the central power station charges should be allotted to the mills.

The question of the power station may be briefly dealt with, as in each case so many circumstances will have to be considered that a general treatment must of necessity be quite approximate. The power station supplying the mills may be gas or steam-driven, and in the latter case coal or gas-fired boilers may be used; or the supply may be derived from a public supply station, which may be compared with the private station, except that it will have a better daily load factor, due to the influence of the diversity factor, and will generally be of somewhat larger capacity. The heavier capital charges and charges for directorate, management, cables, &c., will however be found to completely outbalance any advantages which may result from the better load factor and larger capacity.

Both with steam turbines and large gas engines, the economy does not increase proportionally after a certain output per generating unit is reached. The writer would put this economical limit at 2000kw. for steam turbines, and 1200kw. for gas engine sets. In both cases the price per unit will not be materially different, although in this country as well as in Germany the price per unit delivered to the mains is higher with the large power company than with large private power stations at collieries and steel works, and it is the writer's opinion that as time goes on and the loads increase, the power companies will not be able to catch up with the private power plants at the works referred to.

On a recent tour in Germany the writer found that two large Westphalian power companies charged over 1d. per unit to the collieries in their district. Several large colliery power stations in Germany, and a few in this country (Powel Duffryn Company) produce their own power at from 0.3d. to 0.4d. per unit, including capital charges.

ELECTRICALLY-DRIVEN REVERSING

Works.	Type of Mill.	Product of Mill.					Capacity per hour.	Rolls.		
		Finished Product.	Weight. Tons.	Original Section. Sq. in.	Elongation. Times.	Number of Passes.	Tons.	Diameter. Inch.	Revs. per min.	Type of Coupling.
*Hildegarde Steel Works	Cogging, Roughing, Finishing.	70lb. Rails, 18in. Girders.	2	15 × 15	43	23	15	30	110 to 140	Dir- cou
*Resicsa Steel Works ..	Same. 4 Stands. Billets 1st.	Same, Bars, 2 × 2in.	1 6 3 5	10 × 9 24 × 20	20 4·75	21 19	20 30/35	30 38	110 to 150 35	Gird dire other
*Resicsa Steel Works ..	Plate Mill, 1 Stand. Universal, 1 Stand.	6 m/m. Plates, Loco. Frames.	3·5 3·5	16 × 32 max. 16 × 40	19 15	29 27	30 —	34 30	55 to 150 110	Plate other
*Rombach Steel Works	Bar Mill, 2 Stands.	2 × 2in. Bars, Ties.	2.1	9 × 7	16	13	60/70	32	120 to 160	Dire
Hirstener Steel Works	Plate Mill, 2 Stands.	Plates, 700 m/m. by 4 m/m.	1.25	—	—	17	20	30	120 to 160	Dire
Firming Steel Works ..	Cogging Mill, 5 Stands. Armour Plate Mill.	Bars, 2 × 2in. 8in. Plate.	0.5	12 × 12	36	21	4	28 44	40 to 54	Gear 2 6
†Dorman, Long & Co..	Girders, Rails, 2 Stands.	6in. Girders, Angles, and T Sections.	0.35	6 × 6	24	—	10	16	110 to 160	Dire
Georg Maria Steel Works	Cogging Mill, 1 Stand.	Billets.	2.5	16 × 16 to 20 × 20	15	17	50	36	90	Dire
Rheinische Stahlwerke	Cogging Mill, 1 Stand.	Billets.	2.5 to 3·2	19 × 19	13	15	75	44	60	Dire
*Grille, Funke & Co. ..	Tube Mill.			—	—	—	—	—	50	Gearing
*Georg Tugmayer & Sons	Copper Rolling Mill.	Billets.	3	64 × 6	—	80	3	33	24	Gearing
Hungarian Steel Works	Cogging Mill, 1 Stand.	Billets. Rails.	3 15	22 × 22 5 × 5	21 14	— —	36 18	40 30	94 140	Gearing Direc

* Running.

As to the power stations using the waste gases from blast furnaces, either at their own works or from adjacent districts, the first cost of the power station is considerably larger, at least 60 per cent. more. The cost of production, however, though lower than with coal-fired stations, is not as low as is generally put forward, on account of higher capital charges and special maintenance due to periodical cleaning, &c.

In some of the large South German gas-driven power stations the generating costs per unit are stated to be 0.25d. This figure may be taken as being perfectly well attainable. Much depends, of course, on the price of coal and the value placed on the waste gases. With coal at 6s. per ton the writer has obtained 0.3d. per unit at a large colliery power station with a 40 per cent. load factor. Coal at steel works costs much more at the present time, and in view of the rising prices it is better to calculate with coal at 12s. per ton, and place a value of ¼d. per 1000 cubic feet on the gases. This latter price is low and only represents the price of cleaning, water, &c., and the capital charges on the

ING AND ORDERED IN EUROPE.

Mill Motor.					Flywheel Set.						Power Station.			
Voltage per Armature.	Maximum Torque in Ft. Tons.	Maximum Speed. Full Excitation.	Maximum Speed. Low Excitation.	Maximum Load in H.P.	No. of Generators in Series.	Voltage per Armature.	Type of Motor.	Maximum Speed per minute.	No. and Weight of Fly Wheels. Tons.	Normal Motor Load. H.P.	Primary Power.	Pressure of Supply.	Distance to Flywheel Set. Yards.	Distance from Ml. to Flywheel. Yards.
330	255	110	140	9 000	2	500	3-phase.	375	2 at 26	2,500	Steam Turbine.	3,000 v 50 a.	130	11
550	255	110	150	9,000	2	550	3-phase.	417	2 at 26	2,000	Gas Engine.	5,200 v. 20 a.	615	130
550	255	110	150	9,000	2	550	3-phase.	417	2 at 26	2,000	Gas Engine.	5,200 v. 20.8 a.	615	190
550	295	120	160	12,500	2	550	3-phase.	300	4 at 25	2,800	1 Steam Turbine 2 Gas Engines.	5,500 v. 50 a.	327	16
800	147	120	160	6,250	2	400	Continuous Current.	405	2 at 26	1,500	Gas Engine.	500 v.	327	16
500	131	110	140	3,750	1	500	Continuous Current.	400	2 at 20	800	Steam Engine.	220 v.	272	13
400	105	110	160	3,000	1	400	3-phase.	400	2 at 20	950	P. Supply Company with Steam Turbine.	2,750 v. 40 a.	—	13
750	278	60	90	7,000	3	500	Continuous Current.	450	1 at 35	1,300	Gas Engine.	500 v.	545	54
635	492	40	60	8,400	2	650	Continuous Current.	450	1 at 38	1,600	Gas Engine.	500 v.	0	196
500	48	250	—	800	1	500	3-phase.	500	1 at 5	800	Westphalian Power C.	5,000 v. 50 a.	—	—
550	17	120	—	900	1	—	W'ter Turbine belt driven.	750	1 at 5	—	Water Turbine.	—	0	11
1,000	262	80	140	9,000	2	500	3-phase.	375	2 at 35	1,800	Steam Turbine.	8,000 v. 50 a.	223	21

cond one on order in England

cleaning plant, pipes, and cooling plant. The capital charges, however, are responsible for the second heaviest item in the generating costs and in many cases it will be found to be nearly as economical to have a steam-driven power station with boilers fired with the waste gases, although the efficiency of the gas engine is over three times as great.

With coal at a reasonable figure, a steam station of the outputs met with in large steel works, is not so much less economical than a gas engine station due to the smaller capital charges. The writer favours in many cases a mixed power station with gas-driven blowers and gas-fired boilers for the electrical plant, especially in those cases where plenty of gas is available. The steam engines referred to in the above discussion are all steam turbines, as, for the units in question, reciprocating engines cannot be considered.

In order to put the above remarks in a more comprehensible order the following tables have been made out in each case, based on variable prices of coal, and ½d. per 1000 cubic feet for the gases, 7lb. of steam for 1lb. of coal, 12 per cent. capital charges (5 per cent. interest, 5 per cent. on an average for amortization and 2 per cent. maintenance).

In order to obtain a rough idea of the load factor to be expected in a combined blast furnace and steel works, the following data may be useful: Three sizes of power stations are taken as typical for steel works, in all cases without spare sets, and with coal at 12s. per ton.

In blast-furnace works, day and night shifts are worked at the furnaces, blowers, ore and coal tips, coke ovens, ladles, &c. The same may be said for the mixing department, which is now nearly always to be found in a modern steel works.

In the steel works as a rule there is only the day shift for the two-high, three-high, middle and finishing mills, rod and wire mills, and all their auxiliary plant. The blooming mills, however, are sometimes worked day and night. The daily 24 hours load factor in a *combined* plant is, therefore, very high—over 60 per cent.—while in rolling mill works 40 per cent. will be found an average.

Steam Turbine Plant.

With all modern auxiliaries and coal at 12s. per ton.

Capacity of Power Station without spare. H.P	Units generated per year. Millions.	Daily load factor. Per cent.	Total costs per unit generated. Pence.	Total capital outlay. £	Capital outlay per h p. installed.	Spare plant in per cent.
1,500	6	60	0.45	25,000	11	50
1,500	4	40	0.55	25,000	11	50
5,000	18	60	0.35	60,000	10	25
5,000	12	40	0.45	60,000	10	25
10,000	40	60	0.30	100,000	9	20
10,000	26½	40	0.25	100,000	9	20

The influence of the price of coal increases of course with the capacity of the station as shown in the following table.—

Cost of coal. Shgs.	Generating costs per unit. Pence.			Percentage of fuel costs.		
	1,500 h.p.	5,000 h.p.	10,000 h.p.	1,500 h.p.	5,000 h.p.	10,000 h.p.
10	0.45	0.40	0.30	57	62	65
12	0.48	0.42	0.33	61	66	69
15	0.55	0.45	0.37	64	69	72

Gas-Fired Boilers.

450 cubic feet per unit generated.

Capacity of Power Station, no spares. H.P.	Total capital outlay, including cleaning plant. £	Total generating costs per unit generated. Pence.
1,500	25,000	0.28
5,000	60,000	0.16
10,000	100,000	0.12

Gas Engine Power Stations.

In this case the boilers and costs of stoking, cleaning, &c., are done away with, but the cleaning plant has to be much more efficient, and the engines, dynamos, foundations and buildings are more expensive. The cost per 1000 cubic feet of such a perfected cleaning plant, including tar extractors, dust catchers, long pipe line Bian cleaner, Theisen cleaners, gasometer, water-cooling plant is £10 to £12. As a rule a power station with gas engines will only be considered in cases where large steel works are adjacent to the blast furnaces, so that the quantity of gas has to be sparingly dealt with. On account of the lower load of the gas engine in comparison with a steam turbine of the same maximum load, the capacity of the station has to be about 40 per cent. more, and the stand-by has to be ample on account of the periodical cleaning and maintenance.

Maximum capacity of power station. H.P.	Total capital cost. £	Total generating cost per unit. Pence.
2,100	35,000	0.28
7,000	90,000	0.2
14,000	150,000	0.16

All the above estimated costs are based upon figures obtained from actual practice, high coal prices, high gas consumption of the gas engine, and liberal allowance for capital charges. In many cases even much better results have been obtained. It may therefore be taken that for medium size steel works power can be obtained at from 0.35d. as a maximum to 0.12d. as a minimum per unit, with 0.2d. as a fair average.

As a further proof of these figures the Cockerill works near Liege may be cited, where in 1906 the cost per unit, including capital charges, was 0.17d. The plant consists of five 700kw. gas-driven generating sets and the yearly output is 24,000,000 units with a 50 per cent. load factor.

In order to obtain a fairly correct comparison between the three drives it will be sufficient to obtain the pounds of steam required to do a certain amount of work, or to produce a certain amount of rolled steel, the cost of producing this steam having been stated already; in the case of the gas engine drive, the total quantity of gas; and in the electrical drive, the number of units required. Adding to these figures the costs of wages, oil, waste, &c., and 10 per cent. to 12 per cent. for interest and depreciation on the first cost of the plant, we get the actual costs.

Details of Electrical Drive.

It may be useful, however, to insert a short description of the various methods of electric driving. In the first installations with which the writer was connected, such as the Peine steel works at Hanover compound-wound continuous-current motors were used on account of speed variation and starting torque. The intermediate mills were driven by means of ropes or belts, and the motors as a rule were direct-coupled to the finishing mill, which requires most power. A high-speed (300-400r.p.m.), and therefore cheap, motor could be used, having a heavy flywheel pulley. Rolling mill motors, however, require a double speed regulation. Firstly, various standard speeds

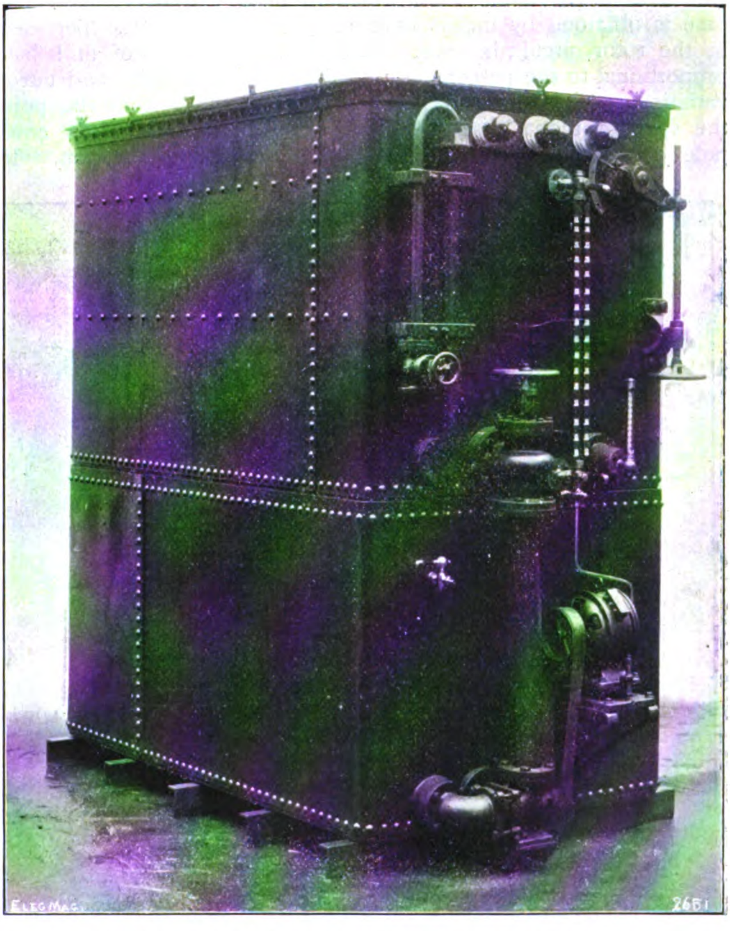


FIG. 3. HOT WATER STARTER FOR A.C. ROLLING MILL MOTOR.

for rolling various materials; and secondly, a drop in speed is required in order to make the flywheel do its duty and give up stored energy with increasing load on the motor. The first condition is met by a shunt motor, but with this class of motor the maximum drop in speed is only 2 to 3 per cent., quite insufficient to induce the flywheel masses to give up their stored energy. A series winding is therefore added to produce this effect. Continuous-current motors are still considered to have some advantages over three-phase motors, especially in connection with the auxiliary plant, such as cranes, rolls, &c. In later installations, however, especially in works where a large central station with power transmission existed, three-phase motors are being more extensively used because of their simpler and more compact construction. The speed variation for both purposes, which in this case is obtained by means of a resistance in the rotor circuit, however causes losses proportional to the percentage of the speed variation. But it is also possible to vary the speed without losses by changing the pole connections. Variations of 1 to 2, or 3 to 4, are possible in that way. A third method is by the use of two motors each for a standard speed, assuring high efficiency for each speed. This latter method has been adopted at one of the new roughing mills at the Hildegarde Works, the mill being rope-driven from one end.

To direct-coupled motors for heavy bar or plate mills, separate flywheels are added by means of flexible couplings. The dimensions of these flywheels depend on the number of simultaneous passes, and the duration of each pass. Heavy flywheels will therefore be found on mills where the material passes but once, or with short passes. In order to obtain efficient flywheel masses, mills of this kind, *i.e.*, plate mills requiring 1000h.p. normal, are driven by high-speed motors (200r.p.m.) and rope-driven, the motor being coupled to a solid cast-steel flywheel, allowing peripheral speeds of 150ft. per second. A considerable number of mills have been equipped on this principle, and have been very satisfactory, both from the point of view of power consumption and equalizing the load in the central station. If further equalizing is

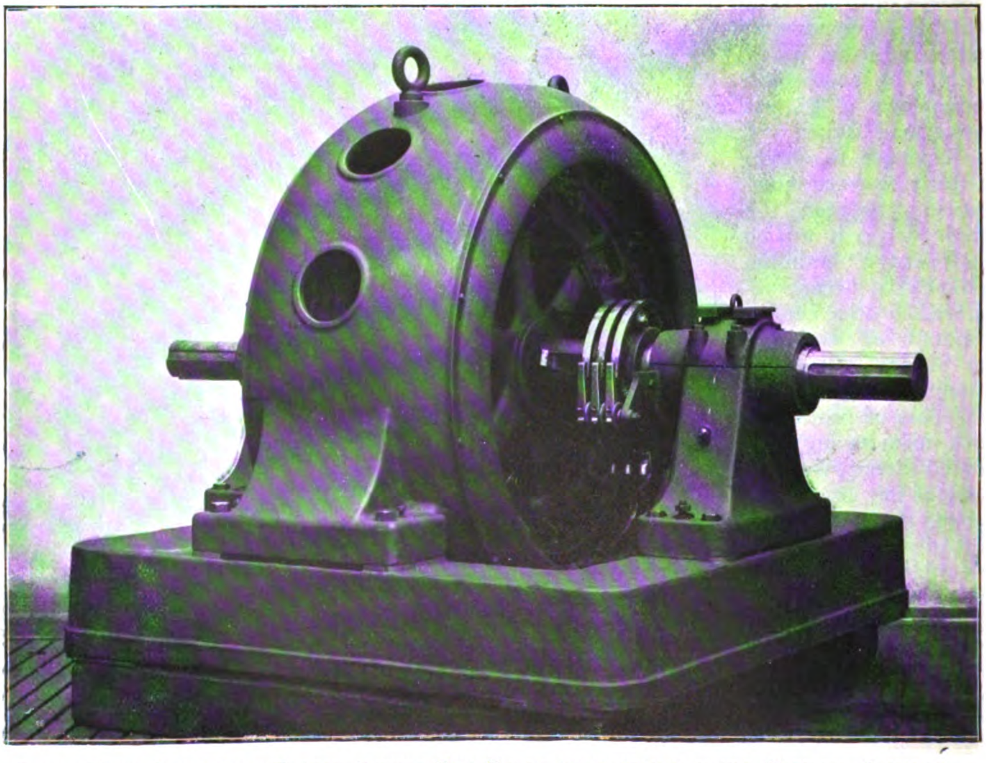


FIG. 4. THREE PHASE, HIGH TENSION, ROLLING MILL MOTOR, 500H.P. NORMAL, 1000H.P. MAXIMUM, 365-270R.P.M.

required, *i.e.*, when rolling mills are on a power company circuit, the well-known Ilgner flywheel sets have to be added. This is, however, a costly addition, and moreover, precludes the use of three-phase rolling mill motors. Lately, however, the writer has been interested in a modified system of this kind, which allows of slightly smaller flywheel sets, which are in parallel with the principal motor. This allows of the equalizer being uncoupled in the case of defects in this part of the plant, so that the three-phase high-tension mill motor can be run directly from the mains. An electrical winding engine on this principle is being erected at a South Wales colliery on the writer's advice, so that further particulars as to the results will shortly be available. Generally speaking, the writer is of opinion that for continuous mills no separate flywheel sets will be required. However, on account of the higher peripheral speeds (over 250ft. per second), it may in some cases be more advantageous to run two or more mills from one flywheel set, instead of installing a number of heavy flywheels (on account of lower speed) on each mill. An additional advantage in this case is the efficient speed regulation by means of variations in the generator field, doing away with all starting losses.

Rolling-mill motors have to be constructed in accordance with the very heavy demands made upon them. They must have a reasonable clearance, and, in any case, substantial bearings. Their maximum load is, as a rule, two or three times the normal rating—more often three times. Their speed variation is, of course, governed by the requirements of the material to be rolled. The heavy duty of these motors, due to their exposure to sudden jerks, was at first considered a serious bar to their introduction by the steel works managers, but it has been proved in actual practice that these jerks do not inconvenience the motor (if properly constructed and designed) more than the steam engine. As a matter of fact, these jerks do more harm to the mills themselves, and the usual safety device which protects the mill also protects the motor. It is, however, necessary to give especial attention to the insulation and mechanical protection of the rotor windings, and especially the end connections, in the same way as this is now being done in turbo-generator work.

The greater number of the continuous mill motors at present installed are of about 500h.p. normal capacity, but some of the heavier plate mills call for much more powerful motors. A few examples of the heavier type may be interesting:—

(*a*) *Dusseldorf Iron and Steel Works.*
  MILL—One three-high stand, 30in. rolls. One two-high stand, 25in. rolls. Speed, 56 revs. to 90 revs.
  PRODUCT—½in. plates.
  MOTORS—750h.p. normal, 1500h.p. maximum; belt-driven; 250-350 revs.; continuous current, 500 volts.

(*b*) *Peine Rolling Mills, Hanover.*
  MILL—Middle mill, 4 three-high stands, 18in. rolls.
  MOTOR—500h.p. normal, 1000h.p. maximum; finishing mill direct, others belt-driven; 160-200 revs.; 500 volts.

(*c*) *Hentschel & Sons.*
  MILL—Plate mill, 4 stands, 80 revs., plates, 30ft. by 5ft. by ¼in.
  MOTOR—1200h.p. normal, 2400h.p. maximum; 320 revs.; belt-driven; 500-volt continuous current.

(*d*) *Deutscher Kaiser Works.*
  MILL—Roughing mill and middle mill, 2 stands, 18in. rolls.
  PRODUCTS—Girders, heavy bars, and mining rails.
  MOTOR—800h.p. normal, 1600h.p. maximum; 225-160 revs.; direct coupled; 500 volts, three-phase.

(*e*) *Deutscher Kaiser Works.*
  MILL—Heavy bar mill, 5 stands: 1 middle mill, 20in. rolls, 80 revs.; 4 finishing mills, 15in. rolls, 160 revs.; serving as finishing mill for (*d*).
  MOTOR—2500h.p. normal, 5000h.p. maximum; 250-160 revs.; 5000 volts, three-phase. Finishing mill direct driven; middle mill rope driven (10 ropes).

(*f*) *Langseleder Tin Plate Works*—
  MILL—Tin Plate Mill, 6 stands, rolling plates ½ to 3 mm.
  MOTOR—450h.p. normal, 900 maximum; 187 revs.; 500 volts, three-phase; rope drive.

These few examples, taken at random, give an idea of the sizes and speeds of various types of electrical mill drives. The heavier and more modern mills are nearly all driven by three-phase high-tension motors. The two-motor equipment is advantageous when two or more fundamental rolling speeds are required, but the system of driving required in each particular case depends on so many additional circumstances, and each case should be considered on its own merits, on competent electrical expert advice.

As to the financial results of the electrical driving of continuous rolling mills, it may be assumed that in most cases, with electric power at sufficiently low figures, as is now being obtained from large power supply companies and steel works power stations, including 12 per cent. for interest and depreciation, electric driving will prove to be the cheaper. Results published from time to time, *i.e.*, lately by the Dillinger Iron Works, in Luxemburg, have confirmed this forecast, just the same as electric driving for pumping, endless rope hauling, and other continuous and non-reversible processes prove cheaper if properly designed and executed. These last points have in many cases not been kept sufficiently in view and the several failures can nearly always be traced to one of these causes. A great deal depends, however, on the price paid for the electrical power. The writer has been closely connected with the development of the electric winding engine, which is more or less on a par with the reversing mill, although not nearly as difficult a problem, and holds that it pays better to wind by electricity than to drive a fan, if power costs anything like 0.25d. per unit. As, however, this question of costs has been most frequently attacked with reference to reversing plant, the writer proposes to give a detailed estimate with costs, in connection with the reversing rolling-mill drive. The best proof of the commercial success of electric driving of all non-reversing rolling mills is the number of installations. In Europe alone, the number of motors installed for medium and heavy mill work is 230, with a normal capacity of 190,000h.p. and a maximum capacity of 410,000h.p. Over 60 per cent. of this number are repeat orders.

Reversing Mills.

Here quite different conditions obtain, and as direct driving by means of gas engines is quite out of the question, the comparison is only between steam and electricity. Both drives are much better adapted to reversing mills than to continuous mills, as the control is entirely in the hands of the engine driver. The principal point is the quick starting and stopping, and these requirements entirely govern the design of both the steam engine and the electric motor. For this purpose it is necessary to know the maximum starting torque and the total energy required in pounds to roll the billets or other material to the required dimensions. Taken over 24 hours, this gives the average load on the motor, and the temperature rise which may be allowed. If an existing steam engine drives the mill it is easy to get at the maximum torque from the dimensions and the efficiency of the gear, and by noting the crank efforts during a complete pass.

Indicator diagrams and speed curves will supply the necessary figures. The maximum torque at full speed, and the magnetic hysteresis to be allowed in the motors practically fixes the period in which the mill can be reversed. This period will be found to be slightly longer than that of a steam engine on account of the heavier rotating masses. At the same time the electric motor offers the advantage of a large overload capacity over that of the steam engine, which is limited by the maximum admission of the steam.

The two principal points to consider in the design of electrical equipments for reversing mills are the quick starting and retardation of the rolls. In order to obtain this it is essential to reduce the forces due to the inertia of the revolving masses. In the first equipments, which are all on the direct-current system, the motor had to be divided into two or three units in order to obtain broader and more compact construction with less flywheel effect. A good steam rolling mill engine can be brought up to speed in 1½ to 2 seconds. The electric motors at the Hildegarde, although calculated to take four seconds, performed this duty in 2½ seconds. This difference is so small that, even with 8 reversals per minute, the time lost is not considerable.

Unfortunately the authorities of the other works where large electrically-driven reversing mills are at present running have not allowed any of their results to be published. As, however, repeat orders have been given by these works, the results may be taken as being favourable. If it can be proved that one electrically-driven reversing mill is a commercial success, the writer holds that as long as no abnormal conditions prevailed, a good case has been made, and a large number of examples are not required to further emphasize this point. At the most, the question of reliability would be further emphasized by the multiplication of the electrical reversing mills.

At the Illinois Steel Works, where a 30in. two-high mill is driven by two 2000h.p. motors, at 0 to 150 revs., reversing every four seconds, the average station load is only 30 per cent. of the maximum load of the mill motors.

The Ilgner method of combining flywheel compensation and Ward-Leonard control is so well known by now that it is not necessary to go into details. Recently the writer had the opportunity of applying another method on much the same principles, but in parallel and not in series with the main motors, to an electrical winding engine. The results are, however, not yet obtainable, but the arrangement, which consists of a rotary converter and separate flywheel generator in parallel, presents the advantages of allowing the use of three-phase mill motors, and the possibility of cutting out the equalizer set in case of breakdown, without stopping the mill, and a power factor of unity. These advantages may or may not counteract the disadvantages of greater power consumption, due to starting losses, but the results from the winding plant will soon give the necessary data in order to come to a conclusion on this point. In most cases, but by no means in all, the addition of an equalizing system will be required, but the cost of such a system will be many times repaid by the smaller power consumption in the power station, and the lower first cost of the prime movers, which need only produce the average load (about 25 to 30 per cent.), instead of being calculated to take the maximum power requirements. The ideal facility of control without loss is perhaps the most striking advantage of the Ilgner system. This system requires, however, direct-current motors, which are limited to a certain extent, owing to commutation difficulties, inertia of the revolving masses, &c. The first drawback can be overcome by the use of commutating poles and compensating coils, and the second by the subdivision into two or three motors. The first plant had three motors, but in all the later installations two motors have been found to be better. The excitation is either compound or shunt, in both cases being supplied from an independent source. The same remarks apply to the construction of the flywheel dynamo, which is subdivided for the same reasons. The broad design of the driving motors and their relatively small

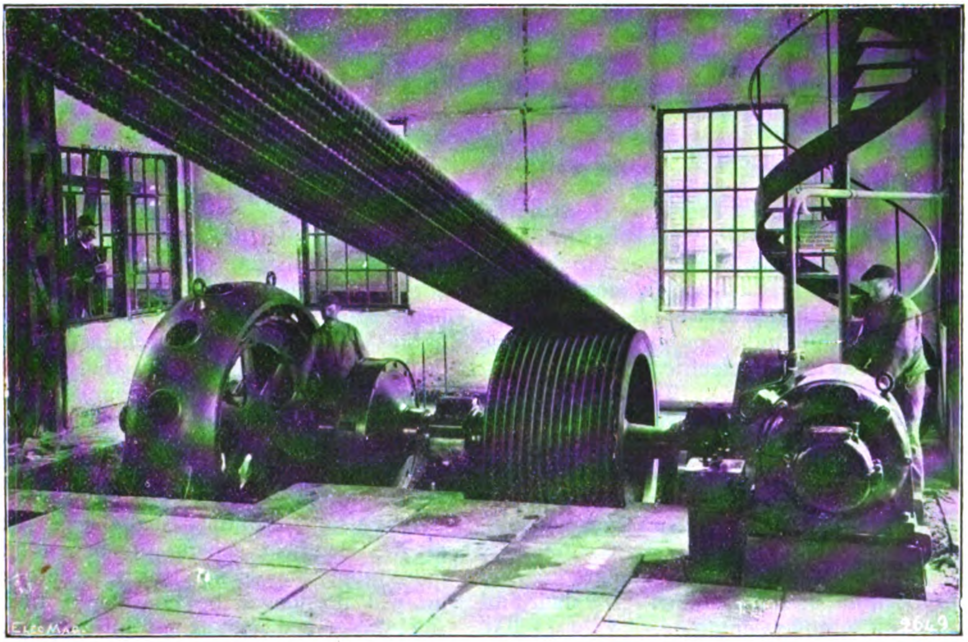


Fig. 5. Electrically Driven Plate Mill, 400h.p.

diameters brings the inertia moment down to about the same as that of the steel gear wheels between steam engine and mill. The absence of this gear is one of the advantages of the electric drive.

In addition to what has been said with reference to the non-reversible motors, extraordinary stresses and jerks in the direction of the shaft have to be provided against.

Commercial Efficiency.

The direct gas-engine drive is, of course, not possible as far as reversing mills are concerned, and therefore the writer will briefly compare the direct steam drive, using the most modern compound condensing engine, with the electrical drive.

An electrical power station is nowadays an integral part of any modern steel works, while for small works a supply from a power company may be substituted. The average amount of power required for rolling is very much less than the actual maximum loads on the mill motors, and it is therefore very difficult and misleading to apportion any part of the power station for the rolling mill service. The price paid per unit should be taken as a basis, and the first cost of the installation should only refer to the actual motors and equalizing plant, as against the steam mill engine. Coal for boilers will be taken as constituting the average practice in this country. Gas-fired boilers or gas engine power stations, as are now mostly found in Continental steel works, of course may introduce some corrections, but as was shown in the beginning of this paper, the difference both in first costs and in working costs is not so large as is generally accepted. From the electric mill installations with which the writer has been connected, he has arrived at the conclusion that the first costs of a modern, twin, compound high-pressure steam engine, together with foundations and buildings, are the same as for the electrical plant (motors, equalizers, cables, &c.). To take an actual example, it may be interesting to calculate the capital outlay and running costs for a mill production of 300,000 tons per year from 2½ ton blooms rolled into ten times the original length for rails, fifteen times for bars, six times for girders, &c. By the methods described before, we get the required energy in foot tons, or B.O.T. units. We shall find that this is equivalent to 320kw. or 435h.p. average load on the mill shaft (taking 300 days, 24 hours). The no-load losses in the rolls, motors, and the electrical losses are proportional to the intensity of the production, the same as has been proved with the electrical winding engines. Taking 45 per cent. efficiency as an average, we get 800kw. on the motor of the flywheel set. The maximum energy can be calculated from the production per hour. This is 1100kw. mean load. At the power station we shall therefore require about 1300h.p., taking 85 per cent. between equalizer, motor, main dynamos and cables, and 1750h.p. maximum. The actual requirements in the power station may be taken therefore at 1500h.p., or about 1100kw. This means that the power station has about 5000h.p. electrical plant installed. Taking coal at 12s. per ton, the generating costs, including all capital charges, will be 0.45d. per unit as a maximum. The total amount of units required per year will be, taking the various products of the mill, about 2,300,000, costing roughly £4000.

The cost of raising steam in a battery of boilers sufficient to supply 1750h.p. will be 3s. per ton of steam, including all capital charges, or taking 30lb. average consumption per effective h.p. hour, as has been found with the most modern compound condensing engines, we get £7000 for the steam required (3,000,000e.h.p. hours).

Another figure which has been taken from the Continental steel works statistics gives 7d. per ton of steel rolled, or £8000 for the cost of the steam production.

The capital outlay, as stated before, may be taken as equal, therefore the capital charges on the rolling mill plant should be taken as equal; wages, oil and waste, repairs, &c., should be less than with steam drive, but for the sake of simplicity they may be taken as equal. A saving of £3000 per annum is therefore assured. Of course many other considerations may alter these figures considerably, and each case must be dealt with on its own merits; but in nearly every case, especially where complete works are concerned, it will be found that the electrical drive is not so expensive as it is made out to be by the more conservative element in the steel works.

It is also to be hoped that the assistance of the electrical expert will be called in more often than is now the case, and that he will no longer be considered by the steel-works manager as an intruder whose assertions must be taken with many grains of salt.

STANDARDISED ELECTRIC PYROMETERS FOR MANUFACTURING PROCESSES.

G. W. HARRIS.

Of the various instruments for electrically measuring temperature at present on the market those depending for their action upon the rise in electromotive force at the junction of two dissimilar metals when heated are the simplest in principle and the cheapest in construction, and as they can be arranged to give a direct reading of the temperature without any calculation or reference to tables they are exceedingly convenient for works use.

Probably the largest users of high temperature measuring apparatus for commercial purposes are those actively engaged in the iron and steel industries. To such the simplicity of the thermo-couple method appeals strongly. The further advantages of standardising the thermo-couple and indicator in the manner described herein will be apparent to all who are interested in the fascinating problem of high temperature measurement either for its own sake or from the commercial standpoint.

This class of apparatus depends for its action upon the fact that if two dissimilar metals (the thermo-couple) be joined together at both ends, and if one of the junctions be at a higher temperature than the other, an electric current will flow round the circuit so formed. If the cold ends be connected together, through a suitable galvanometer (the indicator), a deflection will be obtained proportional to the difference in temperature between the ends of the thermo-couple, hereinafter referred to as the hot and cold junctions respectively. Such deflection can obviously be used as a measure of the temperature of the hot junction and the galvanometer scale be marked off in degrees of temperature.

The principal sources of error are variations in the cold-junction temperature, and variations in the resistance of the circuit. It has also hitherto been a drawback of the method that indicators calibrated for a given thermo-couple could not be used with another thermo-couple even of the same materials, as the electromotive forces generated might be very considerably different at the same temperature.

For temperatures above about 600deg. C. we are practically limited to thermo-couples of platinum and platinum-rhodium, or platinum and platinum-iridium, the alloy containing about 10 per cent. of rhodium or iridium, as the case may be. It has been held that couples of platinum platinum-rhodium are more constant than those of platinum platinum-iridium, but later investigation seems to have established the fact that it is the platinum that deteriorates before the alloy in either case, and hence that platinum platinum-rhodium couples have no advantage in respect to length of life. Platinum platinum-iridium couples, moreover, give a greater electromotive force for a given difference in temperature, a considerable advantage; and further the electromotive force is more nearly proportional to the temperature. Hence it appears that for practical thermometry platinum platinum-iridium thermo-couples have the advantage.

Even so, however, the forces available are exceedingly minute, necessitating the use of a very sensitive galvanometer for the indicator. Moving coil instruments are practically always used for this purpose. The requirements of a good indicator are that it should be sufficiently sensitive, that the resistance should be as high as possible and should change as little as possible with temperature, that it should be unaffected by workshop vibrations, and that it should be able to withstand workshop conditions. Indicators in which the coil is suspended in the magnetic field by metallic strips have the advantage of high sensibility, consequently permitting a high internal resistance, much of which may be of an alloy having no temperature coefficient. In this manner errors due to variations in the resistance of the moving copper coil are swamped. These instruments are, however, less constant in their calibration than instruments having pivoted coils and controlled by spiral springs; they are much affected by vibration, require accurate levelling, the suspension strips are easily broken, and the replacement thereof often alters the calibration. On the other hand instruments in which the coil is supported on pivots at each end resting in jewelled cups, while being more robust, do not permit of such a large proportion of swamp resistance, as the deflecting forces have to be considerably greater owing to the pivot friction. The introduction of Mr. R. W. Paul's single pivot system of mounting a galvanometer coil, in 1903, provided an instrument which struck a happy mean between the advantages of these two systems. In these instruments the coil is circular and carries a pivot at its geometric centre. This pivot rests in a jewelled cup at the centre of a spherical iron core placed between the poles of a permanent magnet. The coil carries the pointer and counterweights in the usual manner and is so adjusted that the point of the pivot is at the centre of gravity of the moving system. A helical spring provides the controlling force, and carries the current to the coil, a light flat metallic spiral completing the circuit. By this method the pivot friction is much reduced and the pivot can be raised from the jewel when the instrument is carried from place to place, thus protecting it from injury. An automatic means of effecting this is provided in the instruments.

One advantage of these instruments for thermo-couple pyrometry is their high sensitivity, which is such that with platinum platinum-iridium thermo-couples for measurements to 1400deg. C., and using a moving coil having a resistance of 10 ohms, the total resistance of the indicator can be brought up to 100 ohms by means of a manganin series coil, thus reducing the error due to variation in the resistance of the indicator to 0.04 per cent. per degree Centigrade. As with most thermo-couple pyrometer outfits the greater part of the error caused by variation in the resistance of the circuit is due to this cause, it will be seen that this error is practically eliminated with these instruments. Other advantages are their freedom from the effects of vibration, their constancy and ease of use; they do not require accurate levelling, and will stand ordinary rough handling without damage. The illustration Fig. 1 shows one of these instruments as made up for portable use. Stock ranges are provided with a millivolt scale, this enabling them to be readily checked for constancy.

As stated above, a matter of considerable practical difficulty is that thermo-couples of the same materials have not always the same thermo-electric forces at the same temperature, different melts of even chemically pure metals varying considerably. This has hitherto practically necessitated the

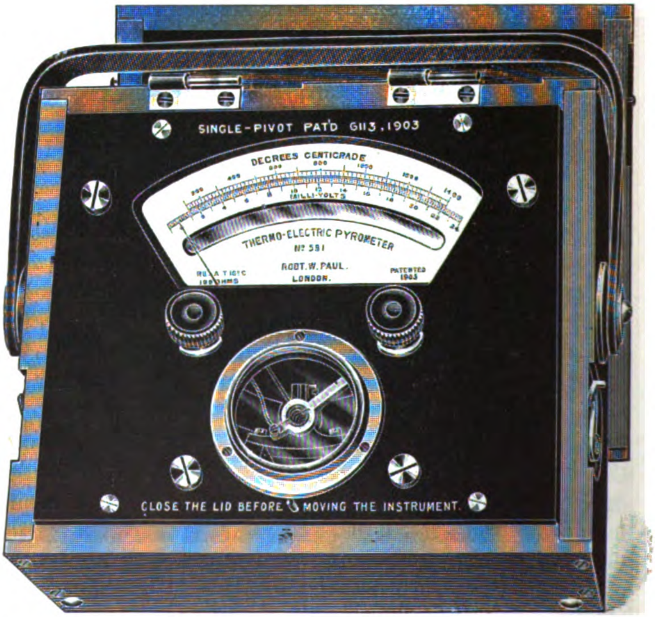

SINGLE-PIVOT PAT'D 6113, 1903
DEGREES CENTIGRADE
200
400
600
800
1000
1200
1400
MILLI-VOLTS
THERMO-ELECTRIC PYROMETER
No. 591
ROBT. W. PAUL.
LONDON.
PATENTED 1903
CLOSE THE LID BEFORE MOVING THE INSTRUMENT.

FIG. 1. MOVING-COIL INDICATOR OF PAUL'S THERMO-ELECTRIC PYROMETER.

calibration of the indicator to the thermo-couple with which it was to be used, preventing anything in the nature of interchangeability, and in the event of accident to either thermo-couple or indicator, both have had to be returned for repair or adjustment.

Steps have been taken to overcome this difficulty, with the result that Mr. Paul is able to supply platinum platinum-iridium thermo-couples which are interchangeable as to thermo-electric force. These thermo-couples are brought to a standard resistance when mounted by means of a coil fixed in the head of the pyrometer. Hence, any thermo-couple can be used with any indicator which has been calibrated for these fixed values of thermo-electric force and resistance.

The leads for use with these outfits are chosen of such a size that their resistance is negligible compared with that of the whole circuit, or if the run is very long the resistance of the thermo-couple can be reduced to compensate for them. The error which might be caused by alterations in the resistance of the thermo-couple, due to variations in the length exposed to the furnace heat, is very small, and is largely allowed for by assuming a mean length for the insertion of the couple into the furnace, and taking this into account in calibrating the indicator.

With regard to the question of cold-junction temperature, if precautions are taken to screen the cold junction from the furnace heat the error due to this cause can usually be neglected in commercial work, but if it is necessary to work to the greatest possible accuracy, the temperature of the cold junction can be taken with a mercury thermometer, and its variation from standard temperature added to the indicator reading if it be high, or subtracted if it be low. When required the pyrometers can be fitted with a simple little device for overcoming trouble from this source. The head of the pyrometer is fitted with a secondary thermo-couple which dips into a readily removable glass vessel protected from mechanical injury by a metallic sheath. This glass vessel can be filled with water at the standard temperature. This secondary thermo-couple is connected in series with and in opposition to the thermo-couple proper, and its effect is to make the readings on the indicator a measure of the difference between its temperature and that of the hot junction. Thus when it is at the standard temperature, the readings obtained are correct. A temperature of 16deg. C. has been adopted as the standard cold-junction temperature with this apparatus, as this is a more suitable temperature for instruments for works use than zero, which generally necessitates the use of melting ice at the cold junction if an accuracy within from 10deg. C. to 20deg. C. is required. The second illustration shows the head of a pyrometer fitted with this attachment. It can also be arranged for connection to the water mains to allow of a constant stream of cold water to be maintained.

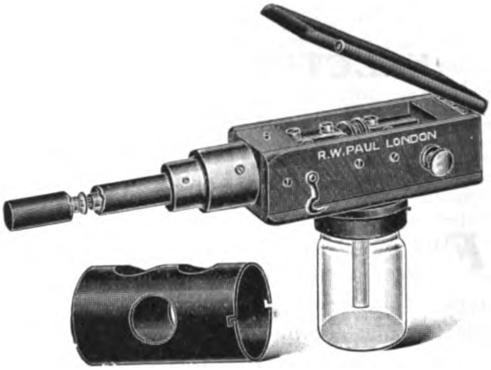


Fig. 2. Pyrometer Head with Water-cooled Cold Junction.

These standardised thermo-couples are mounted in a variety of sheaths dependent upon the purpose for which they are to be used. They range from a small couple for use in dental furnaces, having a capacity of about 1 cubic inch, to couples 5ft. to 6ft long. Some are mounted in double weldless-steel sheaths for hardening baths, with flexible continuations to the cold-junction box; some are in simple steel tube sheaths for moderate temperature furnaces for such purposes as annealing; while others are mounted in porcelain or fused silica tubes for higher ranges. These are all made electrically interchangeable in the manner indicated above, and the destruction of a couple does not necessitate the recalibration of the indicator to suit new couple wires, neither does accident to the indicator necessitate return of the thermo-couple to the maker. Provision is also made to enable the sheaths to be readily changed as they burn out, or in case of damage.

ELECTRIC BLOWERS FOR CUPOLAS AND FURNACES.

FOR some time past there has been a keen struggle between the positive type of blower and the centrifugal blower for the mastery in cupola blowing service, and it would seem that the latter type, the centrifugal fan, is rapidly coming to the front. Whilst the rotary type of blower has made very little advance, and stands practically where it did many years ago, the centrifugal blower has been greatly developed; with modern types of centrifugal blowers very much higher efficiencies are obtainable than were possible a few years back, and moreover these better results are obtainable at lower and more practicable speeds than heretofore. One of the latest types of blowers on the market gives an efficiency as high as 70 per cent., which is higher than that obtainable with the rotary type of blower, as used for blowing cupolas, even when the latter are quite new; the efficiency of the rotary machine must become very low when they get worn, whilst on the other hand, the efficiency of the centrifugal blower remains constant throughout its life.

Having excelled in this point of efficiency, the centrifugal blower affords many other advantages. As compared with rotary machines, its first cost is much less, and the expenses of upkeep are also much lower, especially when it is fitted with the modern type of ball bearings, in which the wear is practically nil and friction losses are at a minimum. In view of the very extended use of electrical power in the modern iron-works and foundry, a very important point with the centrifugal fan is its suitability for direct-coupling to an electric motor, or better still, its being designed as a one-piece machine, as illustrated in Fig. 1. This modern arrangement provides a very compact plant, doing away

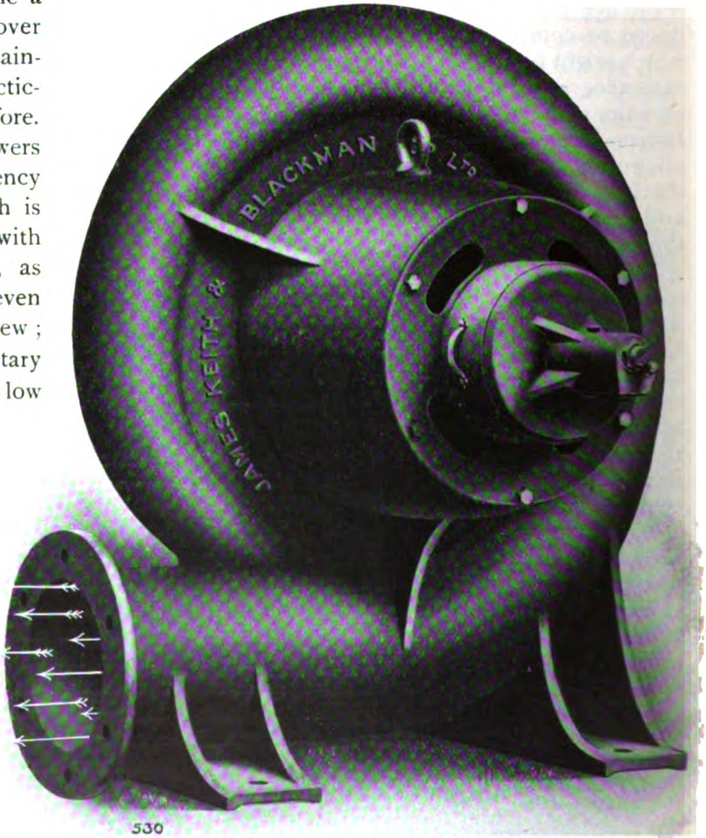


FIG 1. THE KEITH-BLACKMAN ELECTRIC HIGH-PRESSURE BLOWER

with all belt troubles, and placing the bearings under the best conditions, since there is no side pull, and the parts being well balanced, there is very little strain on the spindle or bearings.

The introduction of the fan-type of blower has brought about an alteration to the cupola itself. Much bigger tuyeres and larger cupolas should be used to get the best result with the centrifugal blower, because by this means the lower air pressure can be used to best advantage and consequently much less power is required for the blast. Very satisfactory results can be obtained with from 16in. to 18in. water gauge in large cupolas. These changes in the form of the cupola are further warranted because of the improved effect that using the centrifugal blower has in contrast with a blower of the positive type. With the former type the metal comes down at a much more even temperature, as will be seen: the main difference in the action of the two blasts is that a positive type blower gives a constant volume of air in a series of short puffs with the air pressure rising and falling with the resistance offered by the mass in the cupola, whilst the centrifugal blower gives a steady pressure of air, the volume increasing or decreasing according to the resistance to the air offered by the cupola charge. Experience proves that the latter conditions produce a much more even temperature in the molten iron; the reason for this is probably that when there is a large amount of material in the cupola, a positive-type blower, owing to its forcing the same amount of air through, causes the metal to come down at a very fierce heat, coming as it does through a great depth of fire, and when the mass in the cupola is thin, the metal comes down cold owing to its coming from a short distance with the combustion only being at the same rate, owing to the amount of air not increasing. With a centrifugal blower this variation of the heating effect with the cupola charge appears to adjust itself by the larger mass in the cupola, allowing only a smaller quantity of air to pass through, and though the iron comes down through a greater distance the fire is not so fierce; while when the mass in the cupola is small, a very large volume of air passes and the temperature of the iron is kept up owing to the fire being much fiercer, so that it gets its full temperature even though coming through a shorter distance.

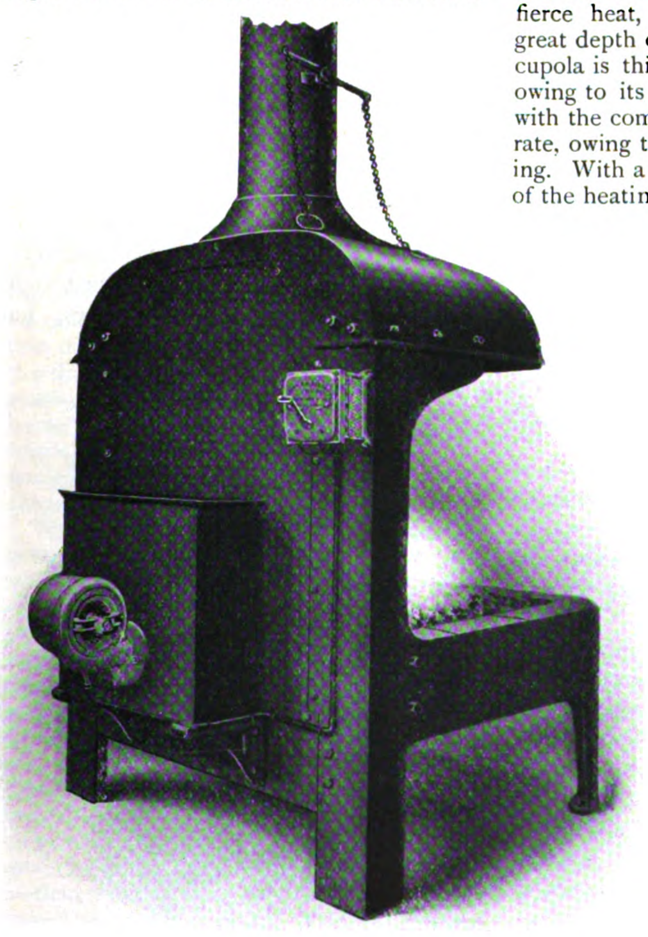


FIG. 2. THE KEITH BLACKMAN ELECTRIC BLOWER FOR BLACKSMITH'S HEARTH.

The high-pressure centrifugal blower is also replacing the rotary-type blower for blowing large forgesand furnaces, especially where the work is scattered and electrical power is available. It is suitable for all work, from the small riveting fires to such fires as would be used for welding 3in. plates. It is easily installed, takes up little room, and is capable, when necessary, of producing a very powerful fire and saving an enormous amount of time in dealing with heavy welding and forge work. The blower is made in one piece, with a series-wound motor, and the blast is started, stopped, and regulated by the electric motor switch. The blower in the case of small fires discharges straight into the tuyere; with larger fires the blast is directed through a short length of pipe into several tuyeres. In Fig. 2 is given an illustration of one of these blowers fixed to the back of an ordinary blacksmith's hearth, with the switch for the starting, stopping, and regulating of the machine shown.

* * *

GEAR DRIVING AS APPLIED TO THE ELECTRIC TRANSMISSION OF HEAVY POWERS.

PERCY C. DAY.

THE rapid strides made during recent years in electric power transmission and in the production of cheap power on a large scale from steam turbines and gas engines driven by blast-furnace or producer gas have caused many large iron and steel works to abandon the old system and adopt electric driving throughout. The modern electric motor delivers power in an almost ideal mechanical form for nearly every purpose, and its steady rotary motion is as near perfection as possible. There is, however, one great drawback to the use of electric motors—their speed.

To obtain the most efficient conversion of electrical to mechanical power it is generally necessary that the motor should revolve at a much higher rate than is either convenient or possible for the machinery which it is required to drive.

It is true that motors can be built for very low speeds, but it is now well known that if certain standard relationships between speed of rotation and power are not adhered to, the inevitable result is a loss of efficiency combined with increased capital cost, which becomes prohibitive if the speed is reduced low enough to drive an average machine without the aid of mechanical appliances for speed reduction.

This indisputable fact has greatly retarded the adoption of electric motors for large works, because it was recognised by experienced engineers that the mechanical means at their disposal for reducing motor speeds were inadequate.

Belts and ropes required too much space to be seriously considered, and there only remained the choice between one or other of the recognised forms of gearing. The worm gear appealed to some, and at first sight it would seem to have advantages, but

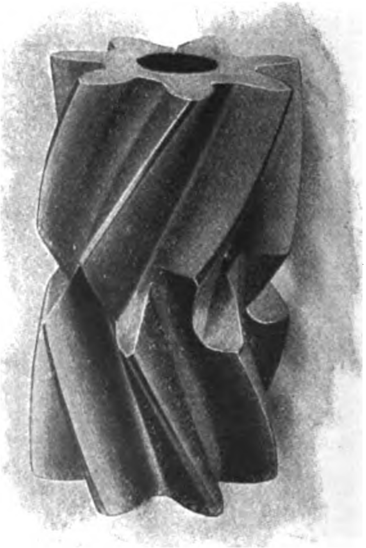


FIG. 1. MACHINE-CUT HELICAL PINION, WÜST TYPE.

experience quickly showed that the best materials and workmanship were not proof against the rapid wear to which this form of transmission is subject if used for heavy powers. As this defect of the worm drive is a fundamental one, it does not seem that anything can be done to avoid it. The problem is one of two sliding surfaces under pressure, and wear can only be avoided by keeping the surfaces out of contact by a film of lubricant. This can only be done when comparatively light powers are transmitted, and therefore these gears are of little use for the class of work under consideration.

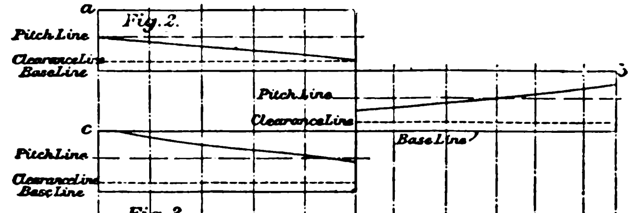


Fig. 2.

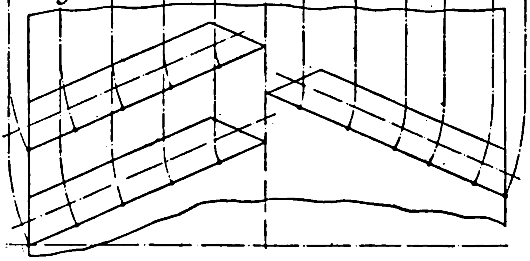


Fig. 3.

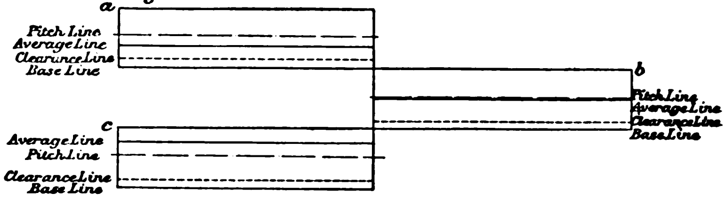
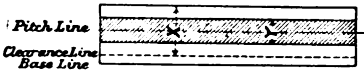


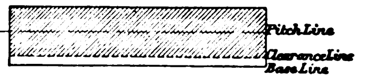
Fig. 4.

Fig. 5.
MACHINE CUT DOUBLE HELICAL (STAGGERED) TEETH. WUSTS SYSTEM



The Shaded Portion shews total Variation of Average Engagement.
Y (Variation of Engagement) - 0.512" - X (Working Depth of Tooth) - 1.167" Proportion - Y - 0.44 X

Fig. 6.
ORDINARY STRAIGHT CUT TEETH



Y - X

ELEC. MAG 2646

Thus by a natural process of elimination the choice was narrowed down to the selection of one or other of the three kinds of spur gearing then available, namely, cast straight spurs, machine-cut straight spurs, or machine moulded double helical gears.

Wheels with cast straight teeth quickly gave place to the straight cut and moulded double helical types, and these two represented the best heavy gear practice for a long time. The cut wheels were more accurate, but their advantage in this respect was discounted by the greater strength and more permanent engagement obtained with helical teeth. It was generally conceded that the ideal gears would be those which combined the advantages of the double helical principle with the accuracy of machine-cut teeth, and some wheels were made by cutting right and left hand helical teeth in separate blanks which were afterwards bolted together in pairs. This method was found to be too costly for general use, and very little was done to improve the status of spur gearing in this country until 1900, when Herr Wüst, a Swiss engineer, exhibited at the Wolverhampton exhibition some double helical wheels in which the right and left hand teeth had been cut in one solid blank. These wheels attracted considerable attention, and the Swiss works were soon unable to cope with the demand. A licence was granted to the Power Plant Company, Ltd., who commenced operations under the Wüst patents, at West Drayton, Middlesex.

Double helical wheels made on Wüst's system are cut from the solid on special machines which work on the "generating" principle. The right and left hand spiral teeth are generated simultaneously, and are staggered in relation to each other by an amount equal to half the pitch. Of all systems of gear cutting that of generating the teeth by means of spiral cutters or hobs is universally recognised as being the most accurate and reliable.

The Wüst wheels therefore combine the advantages of most accurate machining with those obtained by using the double helical tooth form, whilst they possess a special feature in the staggered system of teeth which will be dealt with further on.

It may be of interest at this point to briefly describe the principles which mark the difference between straight cut spurs and double helical gearing. The capacity of a gear tooth to transmit power is proportional to the ratio between the maximum bending stress and the available metal section at the base of the tooth. In ordinary straight spur gears the teeth are subjected to bending stresses which vary greatly during engagement, and which reach a maximum on a driven tooth when the driving tooth first engages it at the extreme tip. Such an extreme condition never occurs with double helical teeth, since the bending stress on a tooth at any instant is the average due to an infinite number of engagements in varying phase. To make this clear the diagram (Fig. 3) represents the development of three helical teeth in a wheel of fifty teeth cut on Wüst's system, which is considered as being driven by a pinion of twenty-five teeth.

The width of this wheel is five times the pitch, and the teeth are cut at an inclination of 23deg. to the axis. The three teeth, "a," "b," "c," which are all in engagement at the same time, are shown in diagrammatic elevation in Fig. 2, and the diagonal lines represent the actual contact between wheel and pinion teeth at the instant when the centre of tooth "b" is engaged at the pitch line.

Fig. 4 shows the *average* contact for these three teeth, for the moment under consideration, obtained by averaging the ordinates of the diagonal lines in Fig. 2.

It will be noticed that the average for "a" is below, and "c" above the pitch line, whilst the average for "b" lies about midway between the other two.

An examination of Fig. 2 will make it clear that "a" represents a tooth which is just commencing, and "c" one that is just leaving engagement, from which it follows that the average line of engagement for any one tooth under full working stress is never higher than that shown for "c" (Fig. 4), or below that shown for "a" in the same figure. Thus there is a zone between which the average contact lies for all phases of engagement, during which a tooth has to bear its full proportion of the load. This is represented by the shaded band (Fig. 5) and the width of this band "Y" is the total variation of average contact. If "X" represents the working depth of the tooth, then "Y" is less than one-half "X."

With straight spurs the engagement varies over the whole height of the tooth, and Y = X (Fig. 6).

The staggered form of teeth in wheels cut on Wüst's system helps to reduce the variation of average engagement and increases the number of teeth in contact at the same time.

The fundamental difference between these wheels and straight cut spurs lies in the maintenance of a continuous and almost invariable average engagement, which produces a smooth motion approximating to that obtained from friction wheels, and entirely eliminates all shocks. Straight spurs, being subject to greater maximum stresses for equal average loads, must necessarily be made of larger dimensions to transmit the same power, and the actual size required cannot be calculated accurately because it is impossible to gauge the effect of the hammering action, which is particularly noticeable when high reduction ratios with small pinions are attempted.

The hammering action often gives rise to serious vibration which, besides setting up incalculable stresses in the gears themselves, produces undesirable effects in the machines which are gear driven, spoiling the quality of the work and sometimes causing accidents by loosening important nuts and keys.

The faults of machine-moulded double helical gears are of a different character and are due to the impossibility of obtaining accurate teeth. As a consequence the teeth never bear evenly over their whole length until the wheels are well worn, and a liberal but indefinite allowance has to be made for imperfect engagement when a set of gears are designed for a particular job. The Power Plant Company claim to produce wheels which can be relied on to bear evenly right across the teeth, and this fact combined with the complete absence of unknown shock factors has enabled them to draw up a definite basis for calculation. It has been found that considerations of wear are of paramount importance for high

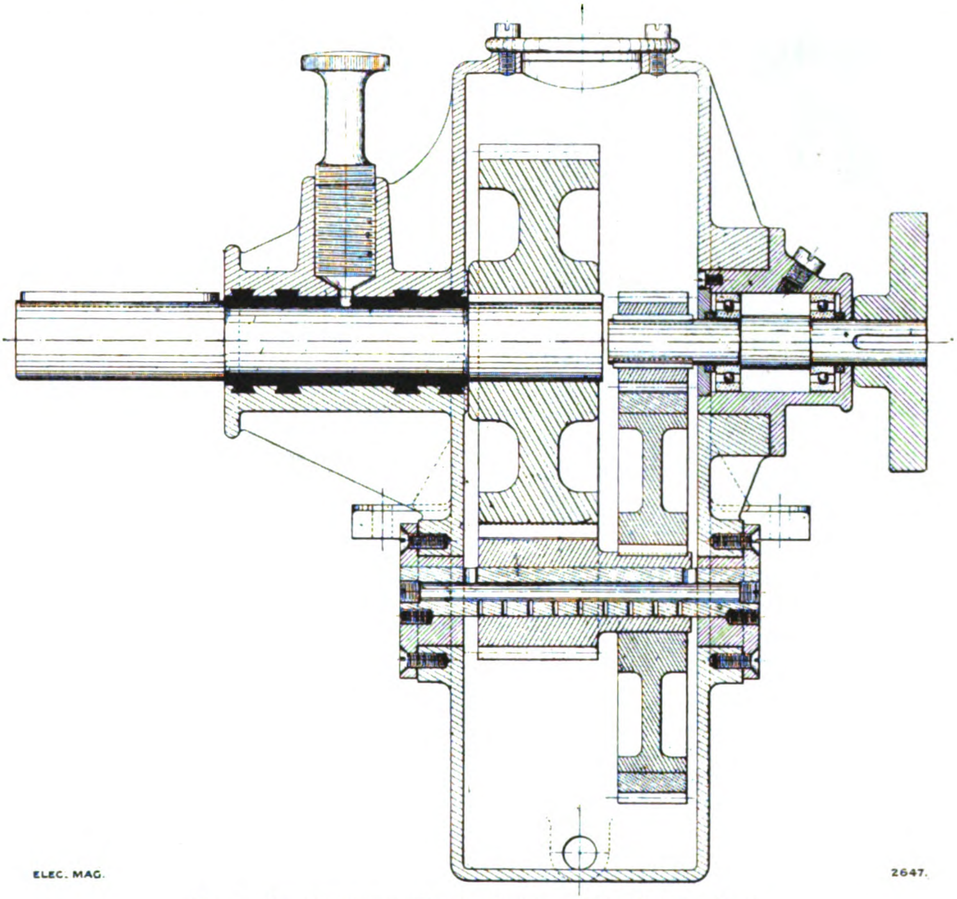


FIG. 7. ARRANGEMENT OF DOUBLE REDUCTION CUT HELICAL GEAR.

speeds, and the stresses allowed are greater for low than for high pitch line velocities, but the factor of safety is in all cases a liberal one and never less than twenty.

Machine-cut double helical wheels made on Wüst's system with staggered teeth, possess one essential feature in which they differ from all other types of solid double helical gearing. The right hand and left hand teeth are not joined at the centre line of the wheel rim, but each side of the wheel is made up of a series of simple helical teeth, with each tooth isolated and complete in itself. This feature has been criticised by some engineers as one which involves a sacrifice of strength because the right and left hand helices do not support each other in the centre. A closer examination of the conditions will show that this is not correct. Each tooth may be considered as a wide beam, fixed at one end, and bearing a moving load. The heavy tooth pressures met with in high power drives must necessarily cause strain, and each tooth in engagement is subjected to a bending action. Accurately cut wheels can be made to bear evenly over the whole face width when running light, but will only continue to do so under heavy stress, provided each tooth bends evenly over its entire length. The free helical tooth fulfils the above condition, but double helical teeth which are joined at the centre line are open to the grave objection that the bending is greater near the edges of the rim than near the centre, so that heavy stresses tend to distort the teeth from their true line of action and the engagement becomes imperfect as the load increases. This defect is often remedied in cast helical gearing by shrouding the teeth at the edges of the rim, but manufacturing difficulties prevent the

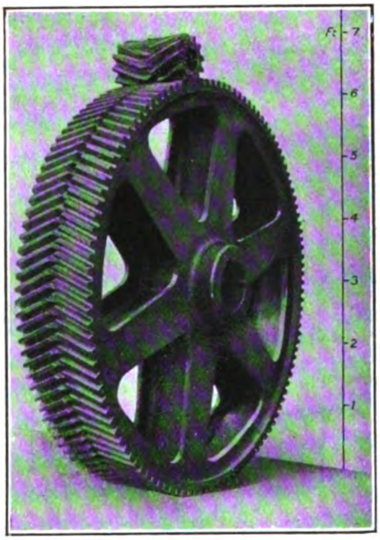


FIG. 8. 330H.P. GEAR FOR ELECTRIC PUMP.

application of the shrouded principle to cut gearing, and it is therefore of advantage to keep the teeth on the two sides quite separate from each other.

All modern machine-cut wheels have teeth which approximate to the involute form, and the engagement between driving and the driven teeth is almost a true rolling motion, whilst the line of contact is near the pitch lines of the teeth, but there is a certain amount of sliding when contact begins and ends. This sliding motion causes considerable wear and loss of efficiency in straight gears, and in such wheels the average motion at any instant alternates between sliding and rolling. With double helical gears the sliding motion is averaged with the rolling motion for every phase of engagement, and the sliding surfaces have never to transmit more than a small fraction of the total load. The wear is therefore diminished and the efficiency increased.

Another important feature of these wheels is the much greater actual contact that takes place, which is due to the finer pitches which are employed and the greatly increased relative width. Contact between two gear teeth is a theoretical line which actually becomes a narrow band by reason of the elastic compression of the metal surfaces under the load. The areas of such bands cannot be measured, but the total is proportional to the length of the engagement line between two teeth multiplied by the number of teeth in contact at the same time. The specific tooth pressure, or pressure per unit area of contact band, is inversely proportional to the total engagement area, and is for this reason exceptionally low for wheels made on Wüst's system. The low specific tooth pressure greatly reduces the wear on the teeth, and in combination with the even engagement and absence of shock, makes it possible to produce perfectly satisfactory gears with ratios which could never be attempted with any other form of spur gearing.

An example of what can be done in this direction can be seen in Fig. 8, which shows a set of gears for a heavy pump drive of 330b.h.p., reducing direct from motor speed of 388r.p.m. to pump at 37.5r.p.m., a ratio of about 10½ to one. The pinion is cut from a solid forging of chrome nickel steel, and has eleven teeth 2in. pitch, with a face width of 14in. The wheel is of cast steel about 74in. diameter. These gears, which must be

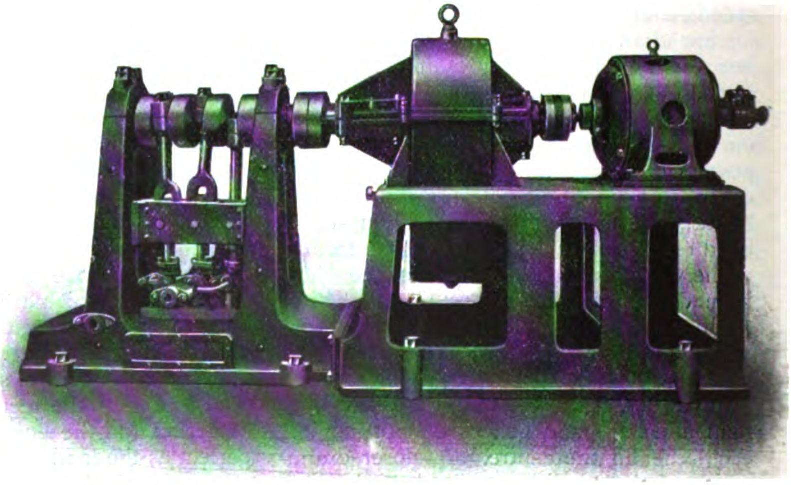


FIG. 9. ELECTRIC PUMP FITTED WITH CUT HELICAL REDUCTION GEAR.

considered of very moderate dimensions for the power, are intended to run in an oil bath. Fig. 1 shows a pinion of seven teeth cut on Wüst's principle, and gives a good idea of the general appearance of these wheels.

The Power Plant Company supply wheels or cut double helical teeth in customers' own blanks. They also manufacture self-contained single and double reduction gears enclosed in cast-iron cases, which serve as oil baths; the former for ratios up to 20 to 1, the latter up to 100 to 1.

These gears are made and standardised up to 200h.p., and the makers claim for them the highest efficiencies possible for gearing, combined with long life and remarkable absence from noise. Fig. 7 shows a double reduction gear in section and explains itself, whilst in Fig. 9 is seen a large gear applied to a three-throw hydraulic power pump.

The gears which have been considered in this article are of the heavy type, but it should be mentioned that the Wüst type of gearing offers similar advantages for lighter motor work where it has been customary to use raw-hide pinions in order to reduce noise. The Power Plant Company's works at West Drayton are now fully equipped for the supply of wheels up to a maximum of 9ft. diameter by 15in. face. A wheel of these dimensions in cast steel with teeth of 2½in. pitch will transmit about 800h.p. at 50r.p.m.

NOTEWORTHY INSTALLATIONS, PLANT, AND APPARATUS.

A Recent Rolling Mills Contract.

For the driving of a rolling mill a well-known Sheffield firm have recently placed an order with Messrs. Marples, Leach & Co. for what will be the largest motor on the Sheffield Corporation Mains. In some respects this motor will be of special type, inasmuch as it is being wound for the high-pressure distributing circuit in that town, viz., 2000 volts, two-phase. Special precautions are necessary for motors designed for these high pressures and intended for steel works service, great care being taken to prevent the possibility of an accumulation inside the motor of the metallic dust always present in such works.

In this particular case the motor is to be placed in an underground chamber excavated in the floor of the mill, this vault being situated about midway between the two sets of rolls which it is proposed to drive. The rolls to be driven by the one motor include one 8in. and two 10in. mills. Rope driving is being adopted for the two larger sets, the ropes running at a speed of approximately 6600ft. per minute ; the 8in. rolls are to be belt driven.

The motor is normally rated for an output of 350b.h.p., although it will be capable of sustaining overloads up to 700b.h.p. without injury. There are three flywheels mounted upon the mill shafts, having a total weight of approximately 15 tons. In order to ensure the flywheels doing their proper share of the work, the motor is specially designed with a very considerable percentage of slip, so that when the load exceeds the normal capacity of the motor, the speed of the latter falls in proportion to such overload, thus transferring the work on to the flywheels. As soon as the bar has passed through the mill, the motor accelerates the flywheels, bringing them up again to the normal speed.

In starting up an electric power system consisting of a motor with heavy flywheels, it is of paramount importance that special care be taken to ensure that no undue fluctuations shall be caused on the supply mains, and with this end in view special starting devices are provided in this case. The rotor windings are brought out to a very large capacity liquid starter, which is provided with a double reduction worm and worm-wheel gear, so that the period of time occupied in accelerating the flywheels is extended to a matter of some minutes. In this way the starting current is very gradually applied and the motor will revolve and gradually take up its speed without absorbing an excessive current. After the motor has reached its normal speed, a brush-lifting and short-circuiting device, which is fitted on to the motor end bearing, is put into operation; this cuts out the whole of the starter connections and lifts the brushes from the rings, thus reducing the wear and tear of these parts of the machine to a minimum.

In order to prevent the possibility of a careless operator throwing in the main switch before withdrawing the brush-lifting and short-circuiting device, a supplementary contact is provided, which trips the overload release on the automatic switch until the short-circuiting device has been opened; this safety arrangement is also connected to the liquid starter in such a manner that it is impossible for the circuit to be closed until the liquid starter has also been brought into the starting position.

A feature of some interest in connection with this particular installation will be the means adopted for ventilating the underground chamber in which the motor and switchboard are fixed. All openings into the pit will be protected as far as possible by means of doors or screens, but a duct of about 18in. square is being constructed, so that fresh air taken from outside the works, near the surface of the river, where the air is comparatively free from metallic dust, is forced through the duct by means of a pressure blower electrically driven. This

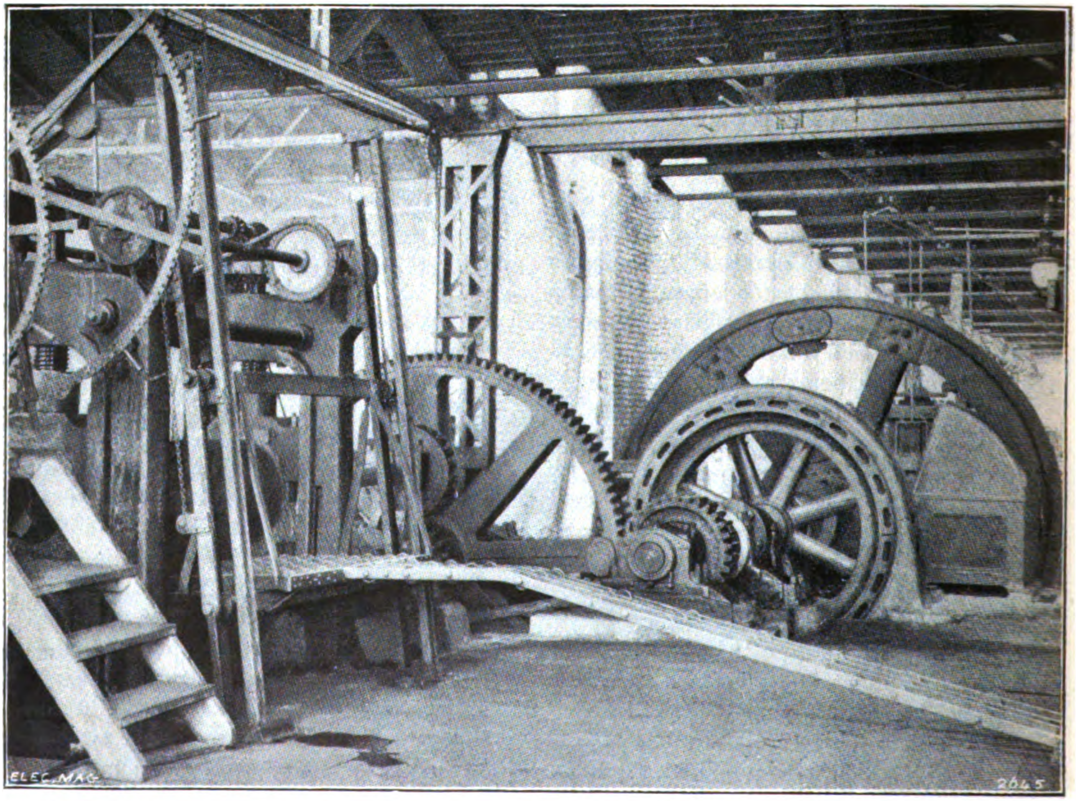


FIG. 1. 700H.P MOTOR, THREE-PHASE, 50 PERIODS, 500 VOLTS, 146R.P.M. DRIVING A ROLLING MILL.

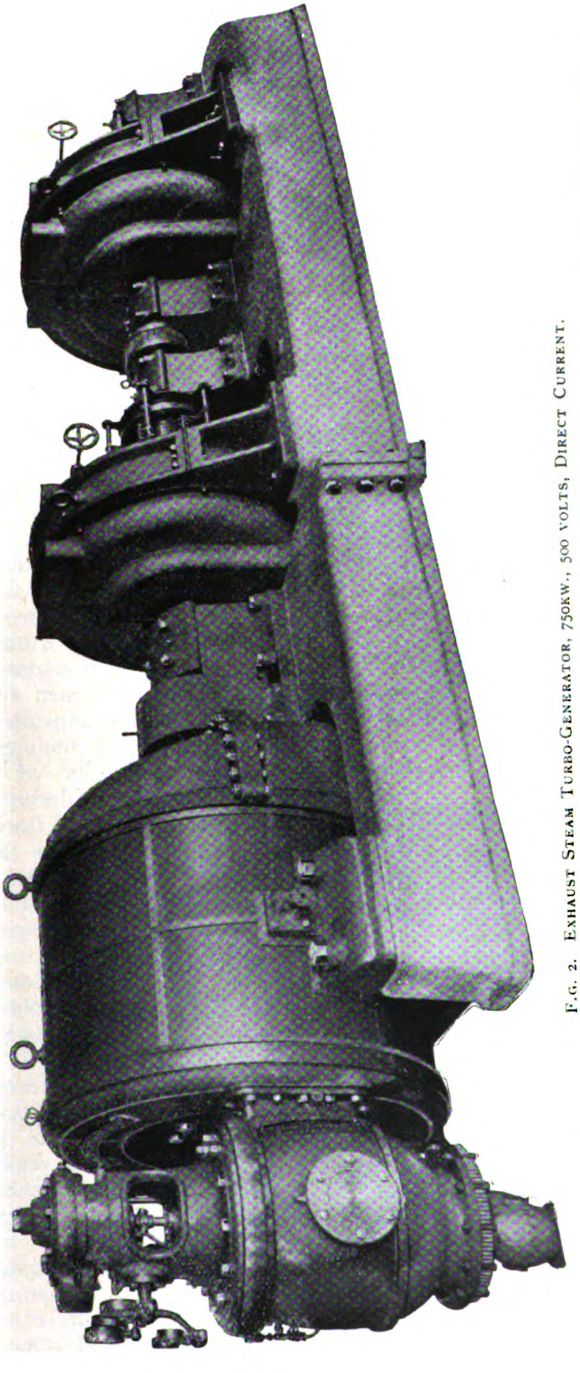


Fig. 2. Exhaust Steam Turbo-Generator, 750kw., 500 volts, Direct Current.

system of ventilation will have the effect of causing any movement in the air about the motor vault to be always outwards rather than inwards towards the chamber, and it has been proved by experience on the Continent that this prevents to a very large extent any accumulation of dust, metallic or otherwise, around or about the switchboard or electric plant.

In order to further ensure that the air supply is free from dust, a coke screen with a running stream of water is provided to cleanse and free the air from dust particles, this being at the inlet to the blower feeding through the air duct into the chamber. The approximate dimensions of the motor pit are—7ft. 3in. deep by 9ft. wide by 30ft. long.

This installation is being provided by Messrs. Marples, Leach & Co., who are the sole representatives in this country for the Bergmann Electrical Works, Berlin. This well-known firm have carried out a very large number of important installations in steel works on the Continent, amongst which may be mentioned the following:

A three-phase motor of 700h.p. to Messrs. Kretzer & Busse, Nieder-Schoeneweide, near Berlin, for driving a mill through gearing. An illustration of this plant is shown in Fig. 1.

One direct-current motor of a normal output of 1000h.p., overload capacity up to 1600h.p., 500 volts, 450 to 600r.p.m., for a wire-drawing mill, at the Hoesch Iron & Steel Works Company, Dortmund.

One three-phase motor, 800h.p. normal, 1600h.p. maximum, 500 volts, 600r.p.m., for rolling mills, at the works of Messrs. Boeker & Co., Schalke.

One direct-current motor of 600h.p. normal, 1200h.p. maximum, and one of 150h.p., all wound for 600 volts, for Messrs. Balcke, Tellering & Co., Hilden.

Messrs. Marples, Leach & Co. have also secured a very interesting and important order which,

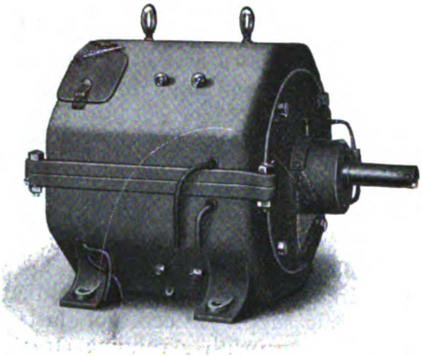


FIG. 3. THE MARPLES-LEACH TYPE "J" MOTOR.

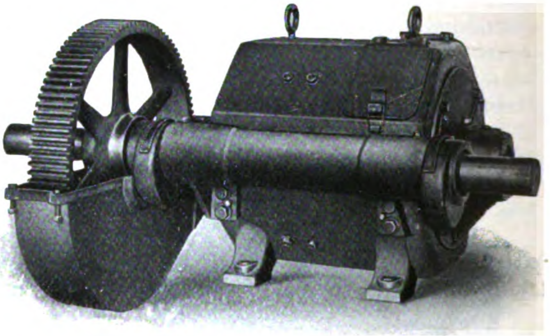


FIG. 4. TYPE "J" MOTOR WITH SPUR REDUCTION GEAR.

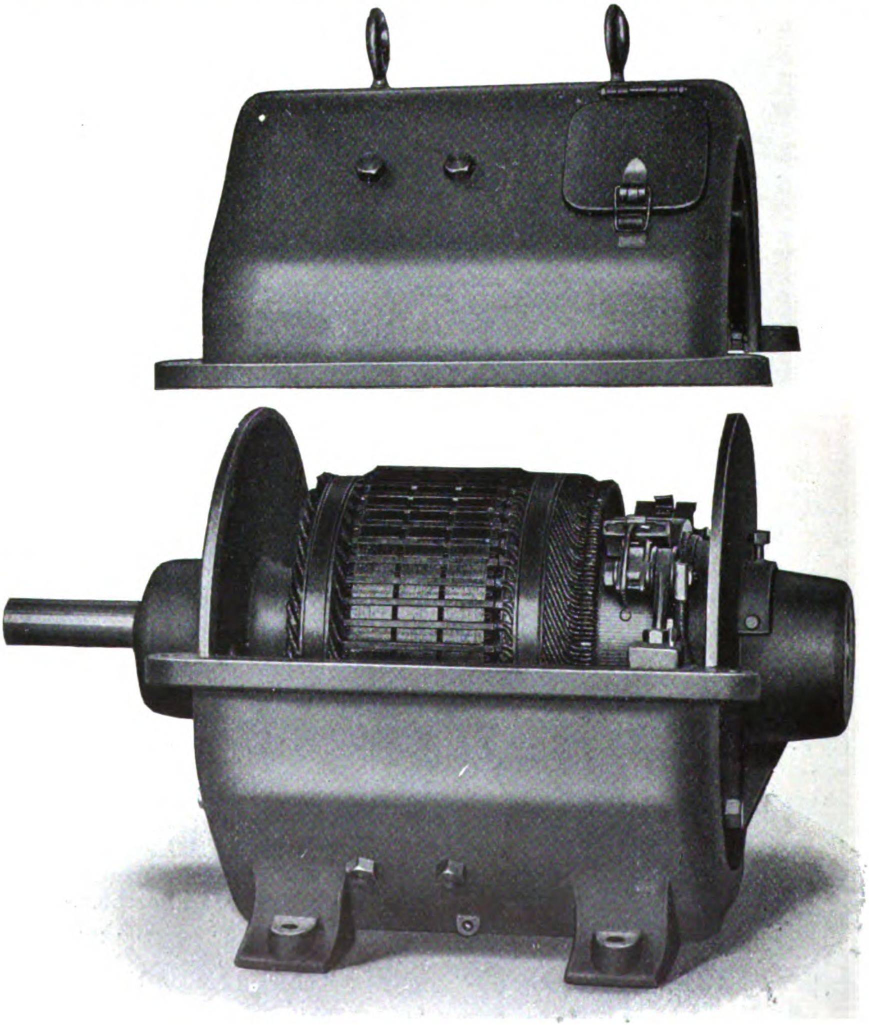


FIG. 5. THE MARPLES-LEACH TYPE "J" MOTOR, DUST AND RAINPROOF.

whilst not for iron and steel works plant, is worthy of mention as illustrating the scope of their work in the industrial applications of electric power; this contract is for the complete electrical equipment for a new cotton mill which is being erected in Lancashire, which installation will consist of—a 1200kw. three-phase steam turbo-generator, engine-room switchboard, one motor of 400h.p., one motor of 350h.p., two motors of 125h.p., two motors of 50h.p., two motors of 20h.p., two motors of 10h.p., besides a number of small motors for driving the auxiliary machinery in the boiler and engine-house.

The turbo-generators manufactured by Messrs. Bergmann, Fig. 2, are earning for themselves a wide reputation. There are several sets running both with exhaust steam and with high-pressure steam. One of the most interesting installations is that which has been running for the last three or four months with exhaust steam from a number of steam hammers, no other steam supply being available. In this particular case, the steel works are obtaining 750kw. of direct-current energy with absolutely no expenditure for fuel. A thermal storage plant interposed between the exhaust steam from the hammers and the inlet to the turbine regulating the supply of steam to suit the requirements of the generator.

In addition to the above-mentioned interesting installation, the Bergmann Electrical Works manufacture a very wide range of all classes of motors for industrial purposes, some of which are particularly suitable for the heavy intermittent work required in steel works for cranes, live-roller gears, shears, punches, saws, and the hundred and one auxiliary machines to which electric motors have been so successfully applied.

In this connection it may be well to mention the new type "J" motor, illustrated in Figs. 3, 4, and 5. This motor has been specially designed throughout for heavy intermittent service. It is made in a variety of sizes from 3h.p. to 100h.p. for direct-current circuits, from 110 volts to 600 volts. The motor is built with an enclosing steel casing of octagonal shape, is provided with exceptionally long bearings, large diameter shafts, massive commutators, and brush gear. It is totally enclosed and dust-proof, and can be used in exposed positions without any extra housing whatever.

The whole of the switch-gear necessary for these motors is provided by the Bergmann Company, the complete range with or without oil-break switches, and for either direct or alternating currents, being provided.

Magnetic Heat Gauge for Steel Hardening.

THE main cause of warping, cracking, coarse grain, and brittleness in hardening tool steel is overheating.

It has long been known to experienced steel-workers that carbon steel, when hardened at a temperature just above what is termed its "recalescence point," acquires extraordinary toughness combined with great hardness, the grain being of the finest. At the same time the change of dimensions is a minimum and the steel is therefore not liable to warp or crack. This correct temperature for hardening varies with each variety of steel or percentage of carbon combined in it. It is stated that the Taylor & Mudford patent heat gauge, as made by Messrs. Taylor, Taylor & Hobson, Ltd., of Leicester, will indicate exactly the temperature at which any quality of steel should be quenched. Its action is based on the discovery that every variety of carbon steel, when heated, becomes non-magnetic precisely at the temperature at which it should be hardened. This statement is strictly true for small masses up to about ⅜ths of an inch square in section. As regards larger pieces it has been found that they must be heated above the recalescence point by an

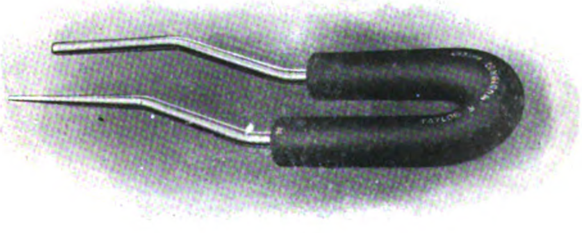


FIG. 1. MAGNETIC HEAT GAUGE.

amount proportional to their size. For this larger work the makers supply a more elaborate magnetic heat gauge and electric indicator for working in conjunction with a muffle furnace.

The gauge for the smaller classes of work is illustrated in Figs. 1, 2, and 3. It consists of a permanent magnet, shaped conveniently for holding in the hand, the poles being prolonged by rods of special metal which remain magnetic at temperatures higher than the hardening temperatures of carbon steels.

A small object may be held across the poles of the gauge above a vessel of clean brine. The object should be heated by a blow-pipe flame, directed from above, and the gauge tilted so that when the correct temperature is reached the piece automatically slides off the gauge into the brine and is quenched.

Fig. 2 shows the method of holding a tap or other piece which requires hardening at one end only. It is placed under the poles or fingers with the end to be hardened under the pointed finger. This end of the tool is heated evenly, and when the correct temperature is reached it drops from the pointed finger as in Fig. 3, but the tool remains hanging vertically on the other finger ready for quenching.

Pieces which are difficult to heat evenly in a blow-pipe, such as small milling cutters, should be heated on a hearth and the gauge applied to the piece being heated. It will be attracted by the gauge until it reaches the hardening temperature, when it should be promptly quenched.

It is said that this gauge is so accurate in determining the hardening temperature proper to every variety of carbon steel, that unless the steel be instantly transferred to the quenching bath the loss of heat during the interval will prevent the object being fully hardened. With this gauge it is no longer necessary to harden even the most difficult shapes in oil or in warm water to reduce risks of cracking. They are hardened perfectly in brine, which is in every case the best quenching liquid.

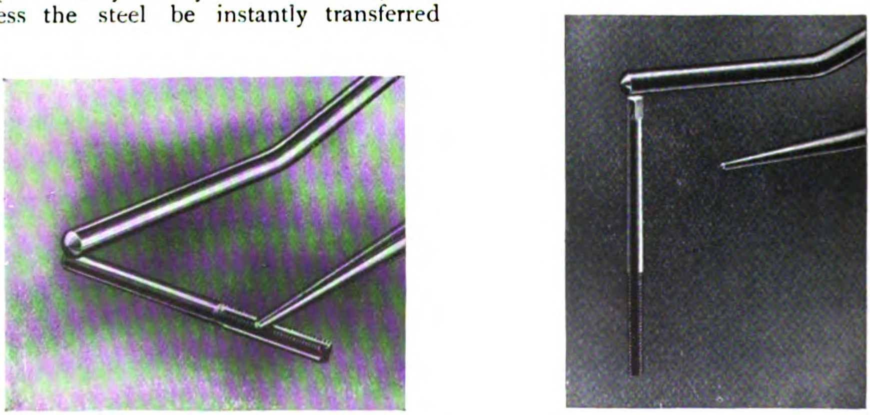
The combined hardness and toughness secured by hardening in this manner at the correct temperature are such that many cutting tools (*e.g.*, milling cutters) may advantageously be used without subsequent tempering.

Brine at about 60deg. Fahrenheit should be used, and is conveniently made by dissolving salt in clean rain-water until the solution is sufficiently strong to float a potato.

The gauge illustrated in Figs. 1, 2, and 3 is suitable for light tools such as small taps, drills, turning tools, &c., having a section not exceeding ⅜in. square. It is not intended for large work.

For larger objects, such as milling cutters, taps, reamers, punches, dies, &c., the magnetic indicator is applied to a muffle furnace, and adapted to ring a bell when the steel reaches the critical temperature (Fig. 4).

One of these furnaces has been in daily use in the tool room of Messrs. Taylor, Taylor & Hobson, Ltd., for nearly two years doing miscellaneous hardening with very striking results. The indications of temperature are so accurate that the usual risks of warping and cracking are absolutely abolished and it is the practice to harden everything,



Figs. 2 and 3. Magnetic Heat Gauge in Use for Hardening Small Tap.

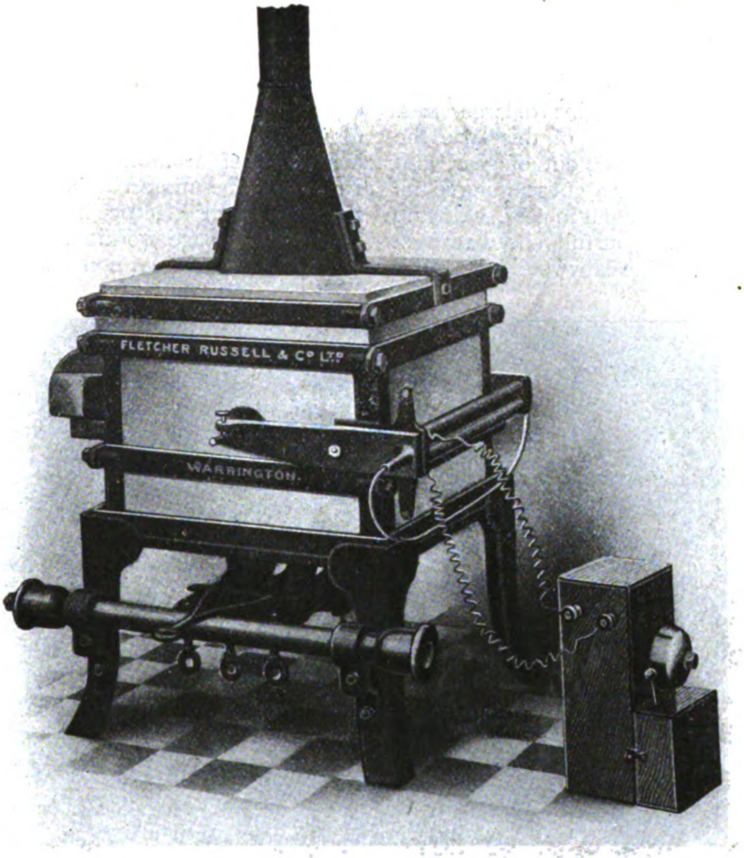


Fig. 4. Furnace fitted with Magnetic Heat Gauge and Electric Indicator.

however irregular its shape, in common brine.

One of the principal manufacturers of ordnance has found that by using the Taylor & Mudford furnace indicator so much toughness is combined with hardness in the tools treated that milling and other cutters can be used without subsequent tempering, and their durability greatly increased.

The hand gauges are marketed by Messrs. Buck & Hickman, Ltd., and the muffle furnaces by Messrs. Fletcher Russell & Co., Ltd.

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Friction Clutches.

The use of friction clutches is perhaps not so general as is warranted by the convenience and economy which can undoubtedly be effected by their use in the majority of power-using works. It may be that this is due to the trouble caused by many of the earlier forms of clutches, which were certainly oftener than not a constant source of irritation and expense. A well-designed friction clutch can be applied with confidence to almost every conceivable drive, but it has required years of experience to design such a clutch, and only those experienced in such matters can even then select the best arrangement of the gear for each particular service. It is therefore not surprising that this branch of power engineering has become the work of specialists. The well-known firm of David Bridge & Co., Castleton, near Manchester, have been engaged in the manufacture and application of friction clutches to all kinds of drives for the past twenty years or so, and claim to be in a position to advise as to the best possible arrangement of such drives, giving a full guarantee that where their recommendations are carried out entire satisfaction will result.

Friction clutches are undoubtedly an acquisition to all internal combustion engines, particularly gas and oil engines of large sizes. In starting up an engine of this type the main clutch is, of course, out of gear, and when the engine has been got running to full speed the clutch can be put in gear, taking up the full load running at full speed without any shock or jar. The Heywood & Bridge patent clutches are widely adopted for this service, being used on gas and oil engines of sizes up to 1000h.p.

Another prominent use of these friction clutches is in conjunction with electric motors for starting up heavy loads after the motor has been set in motion, thus taking a big strain off the motor. This is particularly the case with electric hauling plants for mine and surface working. An interesting example of the great convenience attending

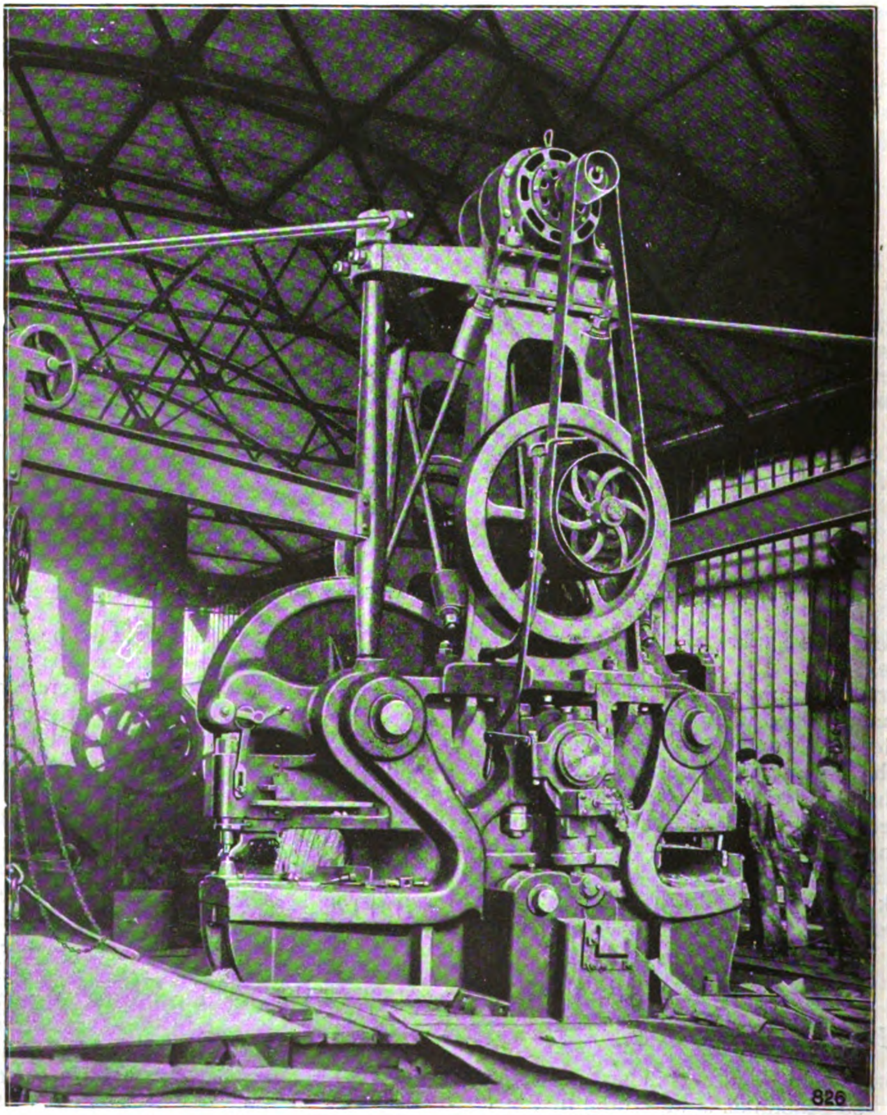


Fig. 1. Crompton Motor driving Punching and Shearing Machine.

their use is afforded by the duplex hauling plants supplied by the firm; with these plants one motor enables hauling to be done from two different workings. If both workings are in order, then both clutches would be in gear, and the wagons would be hauled to a central station. On the other hand, it is quite possible that one working may be stopped; in this case one clutch could be taken out of gear and the other road worked singly.

As said, there are innumerable cases wherein friction clutches can be applied with peculiar advantages. The Heywood & Bridge clutches are designed for main engine transmissions, for subdividing shafting lengths, for starting up heavy and intermittent drives, &c. They are also modified for such special services as require frequent speed changes to be made without stoppage.

Crompton Motors in Steel Works.

THE series of views here given are representative of the wide use to which electric plant, as made by Messrs. Crompton & Co., Ltd., are put in steel works.

Fig. 1 on page 292 shows a combined punching and shearing machine of the lever type. The machine is capable of punching 1½in. holes in 1½in. plate and of shearing the same thickness of plate. The machine is also suitable for punching and cutting steel angles. The motor is placed on an entablature above the machine and drives downwards to the main shaft by means of a belt. This is a satisfactory design as it puts the motor in the most suitable position, and further, it forms a convenient method of converting existing steam driven shearing machines to electric driving.

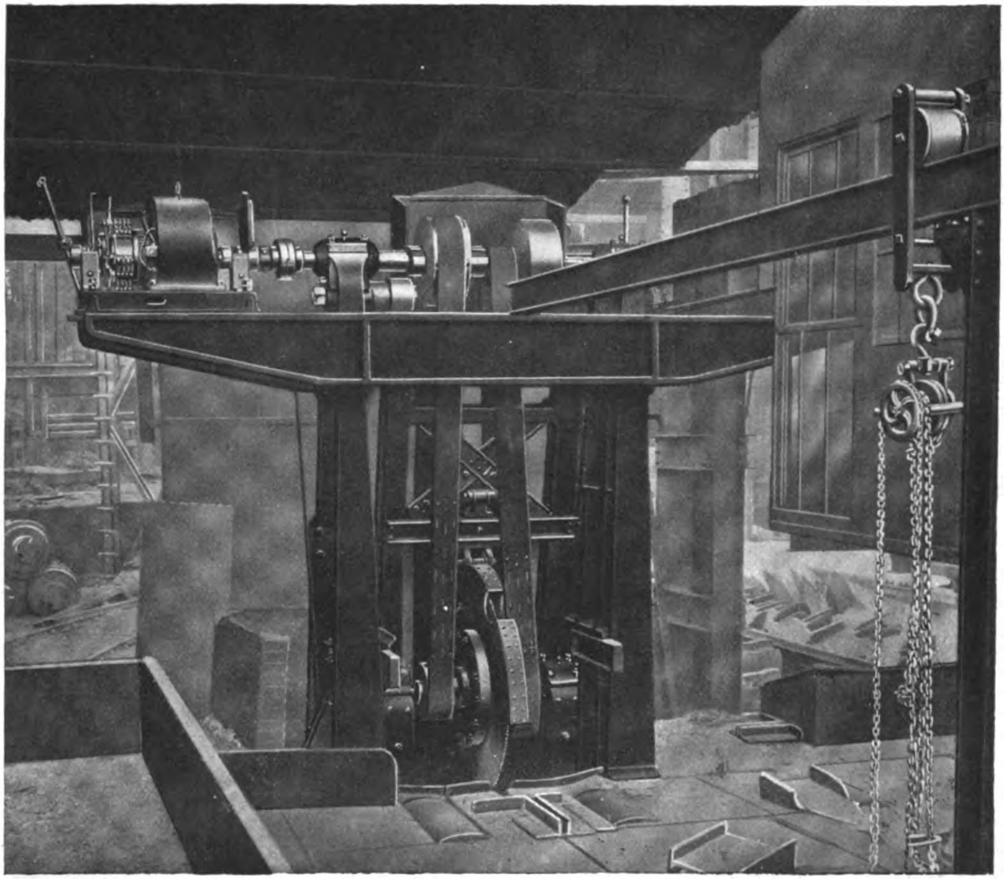


FIG. 2. CROMPTON MOTOR DRIVING HOT SAW.

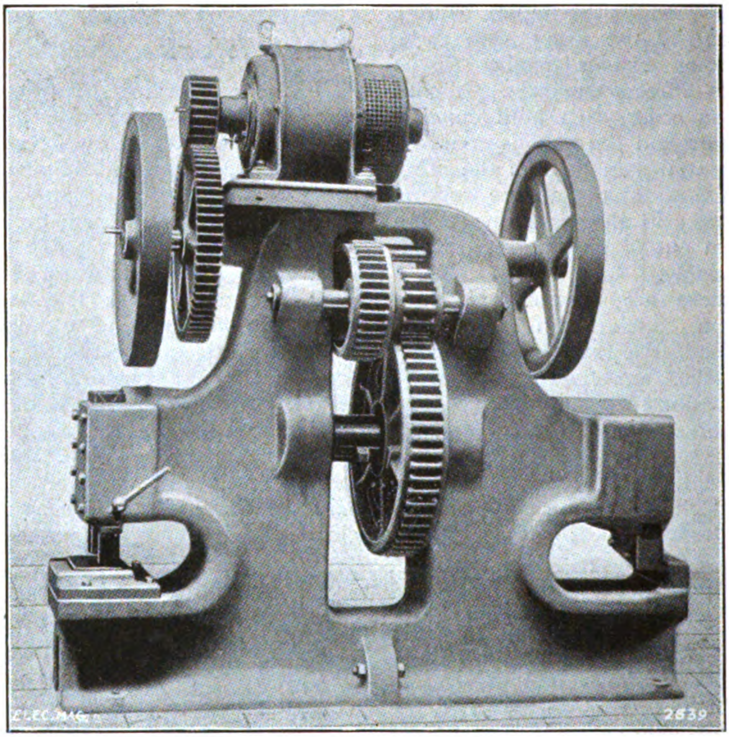


FIG. 3. DOUBLE ENDED PUNCH AND SHEARS DRIVEN BY CROMPTON MOTOR.

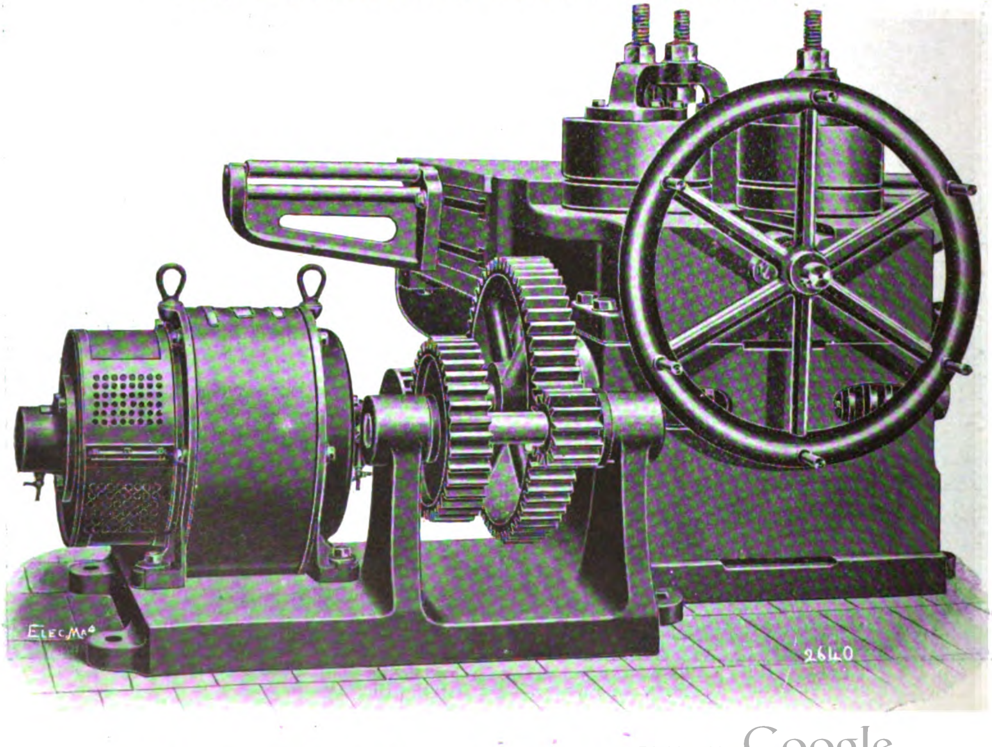


FIG. 4. ANGLE AND TEE BENDING MACHINE WITH CROMPTON DRIVING MOTOR.

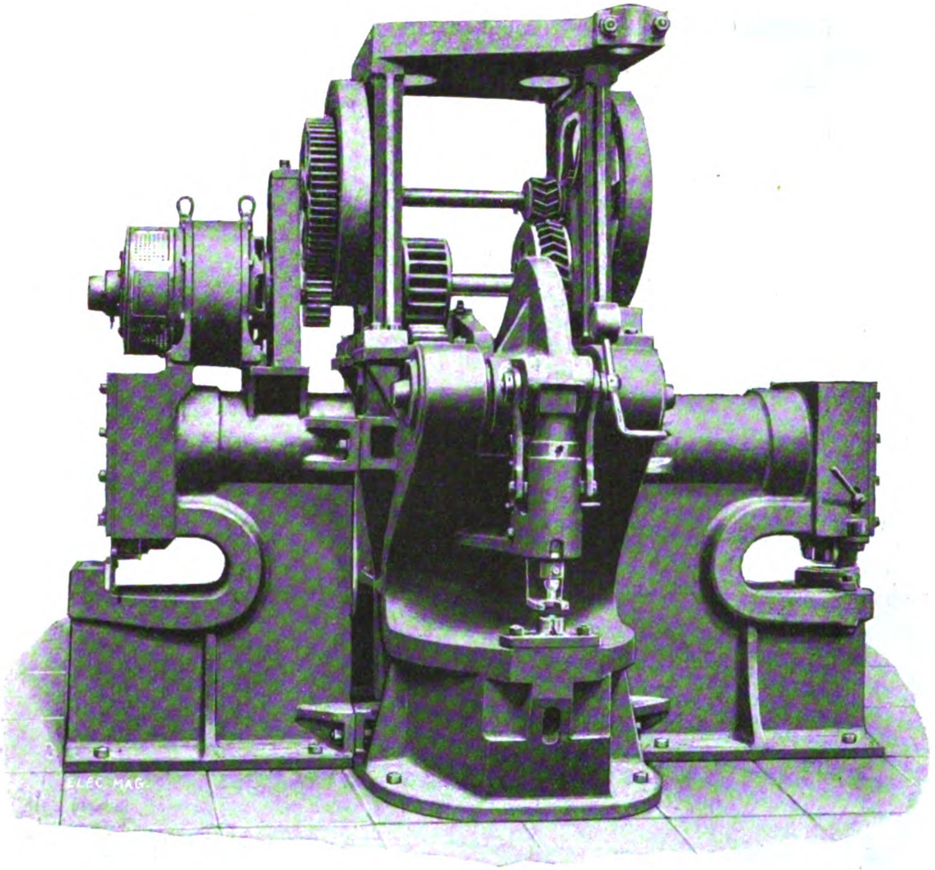


Fig. 5. Quadruplex Punch and Shears driven by Crompton Motor.

The illustration Fig. 2 shows a steel works hot saw electrically driven by a Crompton continuous current electric motor. The motor is connected through a friction clutch to the shafts to which the saw and the travelling gear are belted.

The position of the motor on the top of the machine is exceedingly convenient as it enables it to be coupled direct to the main shaft; it keeps it out of the way of the saw metal on the floor below and enables the cables to be led into it in a convenient manner, as it is practically impossible in such positions to carry the cables underground. The friction switching clutch is put in to save the motor from serious overload in the event of the saw jamming whilst making a cut.

Illustration No. 3 shows another type of punching and shearing machine driven by a motor fixed on the top of the frame. In this case fly wheels are provided on the first motion shaft which balance the load and greatly assist the motor while the cut is being made. The gearing throughout is of cast iron.

An angle and tee iron bending machine is shown in Fig. 4. In this case the motor drives through double reduction spur gearing into bevelled gears which actuate the vertical shafts carrying the bending rollers, the respective positions of these rollers being regulated for the required curve on the section under treatment by means of a hand wheel on the side of the machine.

Fig. 5 on this page shows another punching and shearing machine of a rather more universal nature than those of Figs. 1 and 3. It is fitted with four jaws so that the shearing and punching of different sized holes can be carried out at the same time. In this instance the motor is fixed above the shearing jaws and geared to the principal shafts of the machine through spur gearing.

The last illustration, Fig. 6, shows a Crompton electric motor direct coupled to the shafting and gearing which actuates the live rolls and which bring roll sections to and from the main rolling engines. It will be noticed that the motor and all the gearing is below the floor level, a covering of iron checker plates being put over them. The motor is of the reversing type and is specially designed so as to give quick acceleration to the rollers on being reversed.

"Castle" Motor Drives in Steel Works.

THE upper illustration on the opposite page shows one of J. H. Holmes & Co.'s "Castle" multipolar 15h.p. continuous current motors driving through chain gear a multiple travelling drilling machine having ten drill stocks each capable of drilling holes up to $1\frac{1}{8}$in. diameter, suitable for heavy girder plates, angles, &c., in connection with bridge work and the like. The motor is arranged for variable speed running to allow the cutting speed of the drills to be varied according to the size of hole.

The second illustration on page 297 shows clearly the arrangement of a "Castle" multipolar 25h.p. continuous current motor driving through cut bevel gearing a set of plate bending and straightening rolls. Machines of this type are used in all classes of engineering yards, particularly where constructional work is undertaken and plates for girders, &c., require straightening. The motor runs in one direction always, the reversing of the rolls being obtained by the bevel gear.

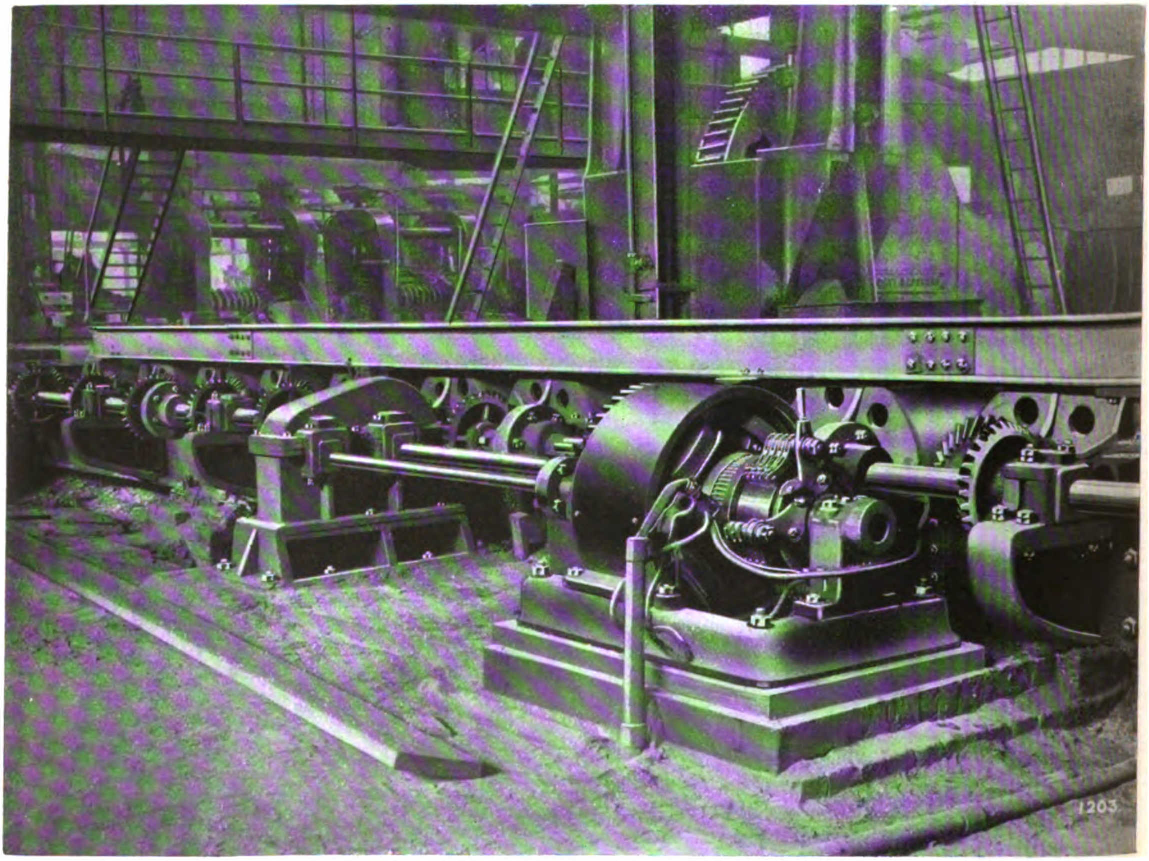
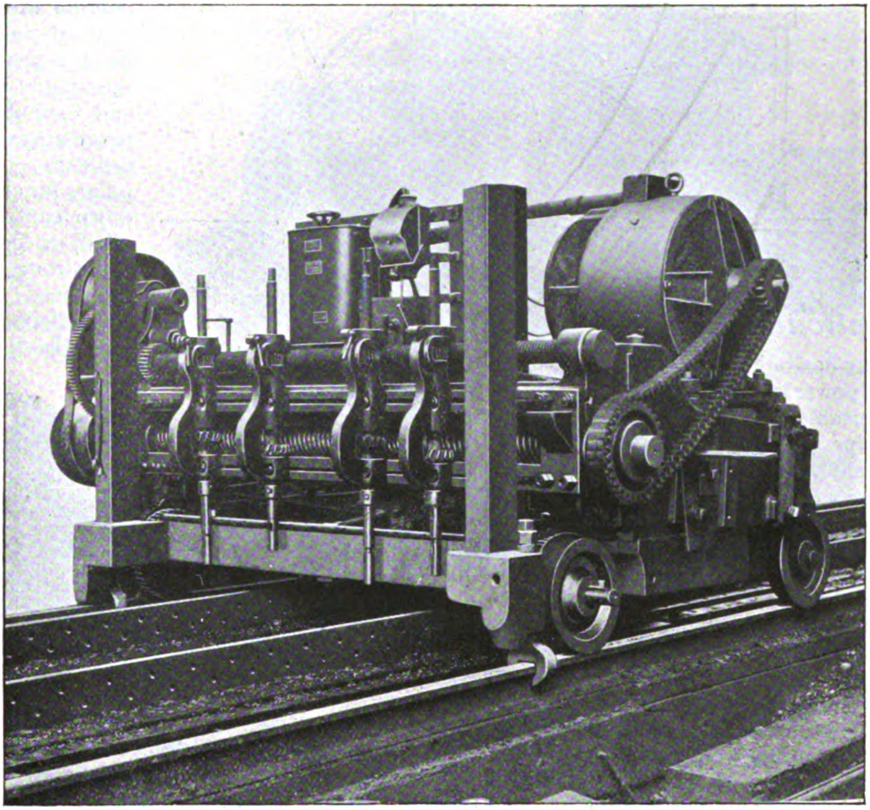


FIG. 6. CROMPTON MOTOR DRIVING LIVE ROLLER GEAR.



MULTIPLE TRAVELLING DRILL OPERATED BY 15H.P. "CASTLE" MOTOR.

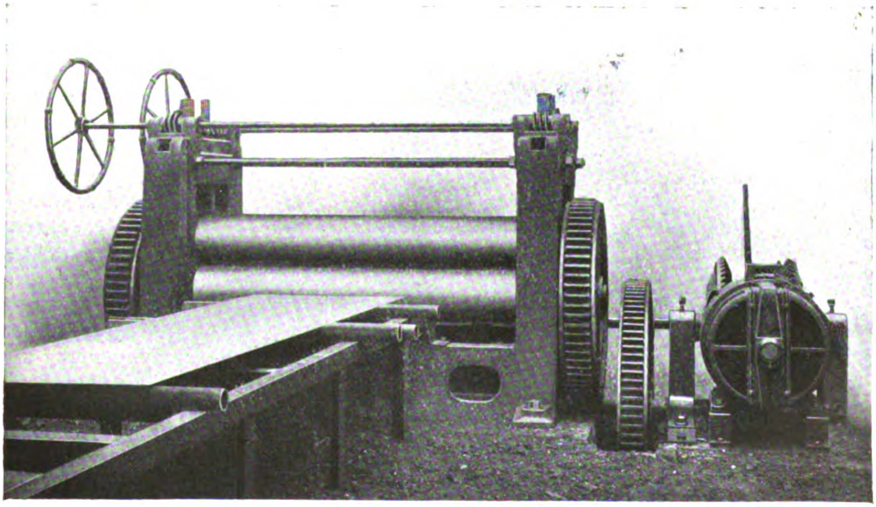


PLATE STRAIGHTENING ROLLS DRIVEN BY 25H.P. "CASTLE" MOTOR.

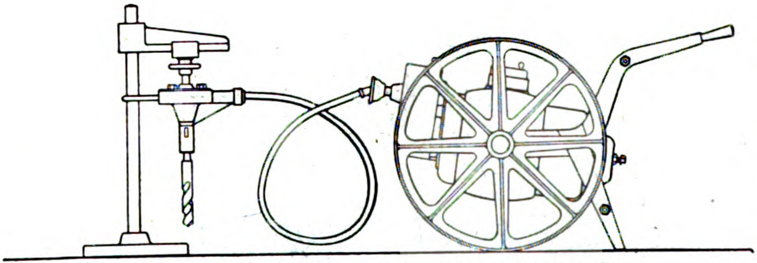


FIG. 1. PORTABLE ELECTRIC DRILL BY ELECTROMOTORS, LTD.

Portable Tools and Motor Applications.

THE flexibility and convenience of electric power is very apparent in the many types of portable electric tools now on the market and for which there is such a very large demand that many firms make their manufacture a standard line. The portable truck drill, shown in Fig. 1, is one of the products of Messrs. Electromotors, Ltd., Manchester. On account of the large amount of drilling in confined and awkward positions which constructional engineers and others engaged in the machining and handling of iron and steel in large bulk have to do, the makers have standardised this portable truck drill. Briefly, it consists of a swivelling motor hung on a light truck and connected to a drilling head by means of a flexible shaft and universal joint. The motor is so arranged that it can be locked in any position, and on the larger sizes, as illustrated, enclosed gear boxes for speed reduction are fitted. The whole equipment is strong and thoroughly reliable and suitable for rough usage. Either ordinary drilling pillars for clamping down can be supplied, or pot magnet pillars, consisting of a strong electromagnet, by which the drill-head is held magnetically, can be used for attachment to larger surface work such as blank plates, girder webs, &c.

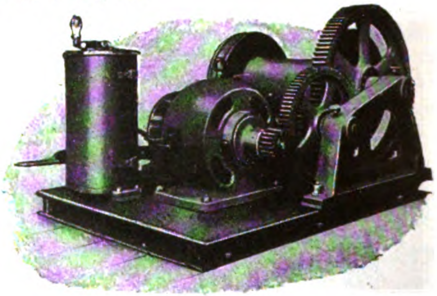


FIG. 3. ELECTROMOTORS ELECTRIC WINCH.

The illustration Fig. 2 shows a direct-current, protected-type motor by Electromotors, Ltd., driving a cold saw through spur and bevel gear. As will be seen from the photograph, the arrangement is essentially rigid and compact.

Fig. 3 illustrates a standard direct-geared electric winch as made by Electromotors, Ltd., and suitable for lifting and haulage work in iron and steel works. The construction is heavy but simple, and generally consists of a drum, direct - driven through spur gearing by a reversing motor. All the spur gearing is machine-cut, and care has been taken in the design to obviate twisting of cross shafts, &c. The motor is provided with either an electric or foot brake, and is started and regulated by

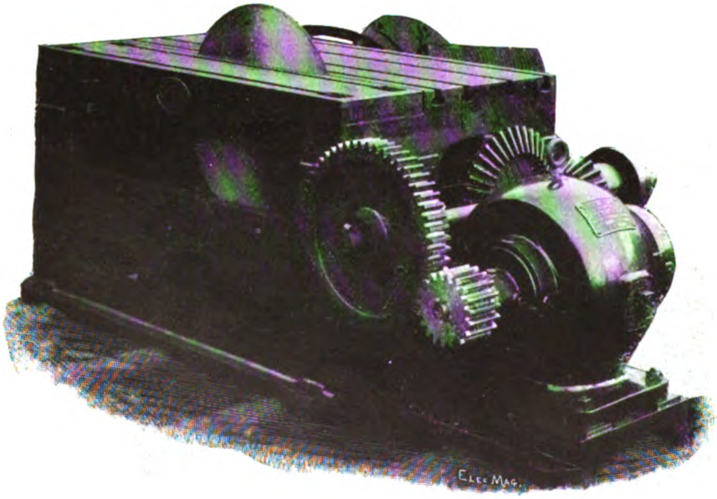


FIG. 2. COLD SAW DRIVEN BY ELECTRIC MOTOR (ELECTROMOTORS, LTD.).

a tramway type reversible controller. The whole, including the winch, driving motor and controller, is mounted on a substantial wrought-iron base, this construction being the most suitble for withstanding the severe shocks to which these hoisting gears are often subject.

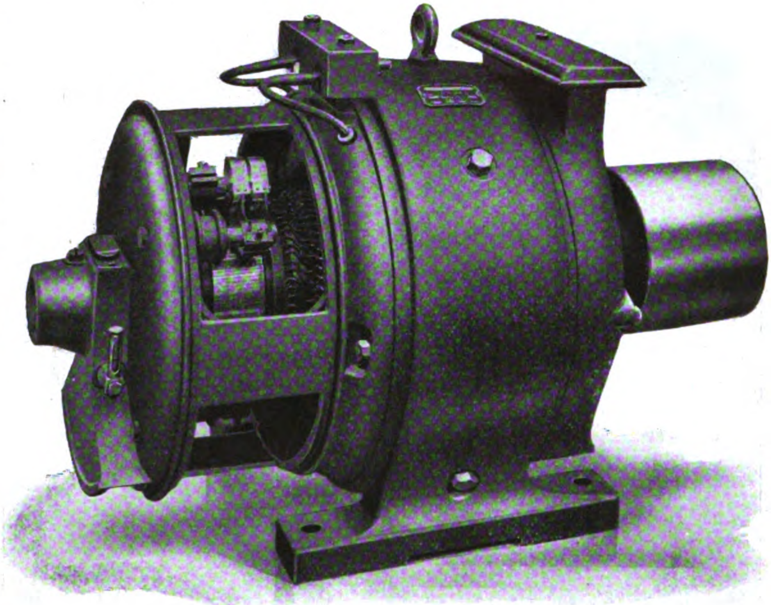


Fig. 1. Union Electric Direct-current Motor.

Union Electric Motors.

The Union Electric Company, Ltd., has for many years given a great deal of attention to the manufacture of electric motors for both direct and polyphase current working. For direct-current circuits the machines are generally constructed in two outfits, viz., the open protected type and the enclosed ventilated type outfit. The open protected type is the standard one for most requirements because it gives very easy access to all parts, together with perfect ventilation and ease in handling.

The enclosed ventilated outfit is exceedingly ingenious, and it is to be recommended for exposed positions where protection is required against falling material such as metal chips or shavings, &c. It is, moreover, entirely rainproof, and will be found suitable for most situations where falling water is present.

A special arrangement fitted to this machine is the fan draught ventilation, which consists of a fan fixed on the motor spindle and revolving in the end shield at the pulley end. The effect of this fan is to induce a

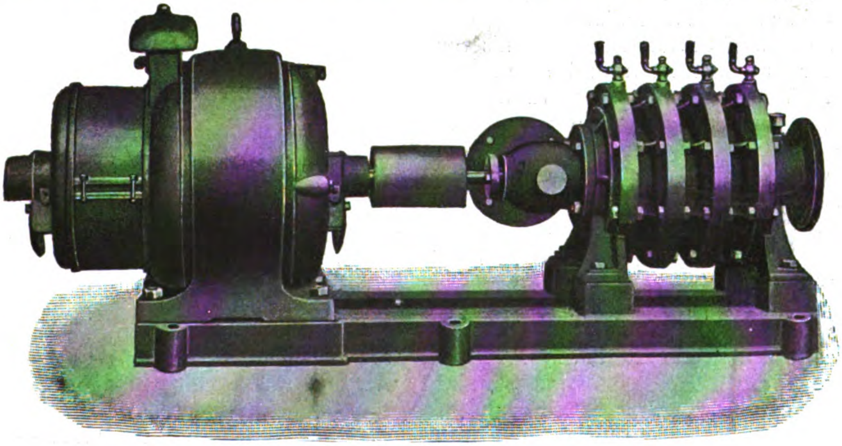


Fig. 2. Union Electric Motor driving Centrifugal Pump.

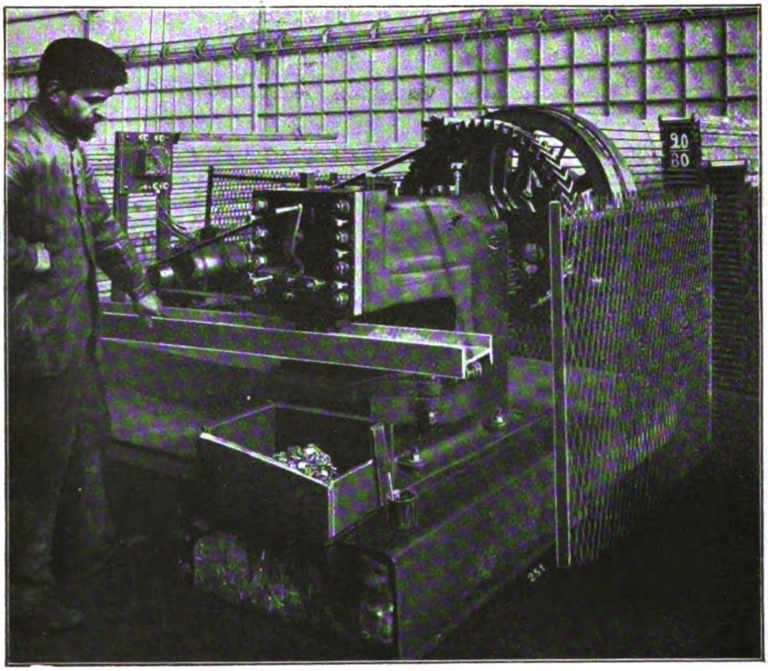


FIG. 3. UNION ELECTRIC MOTOR DRIVING GIRDER PUNCH.

definite draught of air through inlet ducts in the commutator end shield, thus securing a flow of cool air over the commutator through the armature ducts and interstices; the warm air is then expelled through outlet ducts at the pulley end of the shaft.

By this means very cool running is secured. The temperature rise on the windings and commutator is kept within very low limits, and for a given size the rating of such a motor can be somewhat increased as against a similar machine without a fan draught arrangement. This type of motor is constructed and supplied in sizes ranging from ¼b.h.p. up to 120b.h.p.

With regard to polyphase motors, the Union Electric Company have just issued their very comprehensive list No. 1007; this list gives a complete range of the standard polyphase motors running at synchronous speeds of 1500, 1000, 750, 600, 500, 428, and 375r.p.m., and for powers ranging from ¼b.h.p. up to 350b.h.p. These motors can be supplied for all standard voltages up to 5000, and the maximum pressure for which the several standard machines can be wound is stated in the list.

The motors are wound for a standard frequency of 50 periods per second, but can be wound for frequencies of 40 periods and 60 periods as desired. With the altered rating of speed special quotations will be given for motors wound for 25 period circuits. The Union induction motors can be supplied for either two or three phase circuits.

The construction of the machines is very solid, and they will stand a great amount of rough wear and tear in actual work. They are constructed generally in the open protected style which meets with most requirements. They can, however, be supplied, if specially required, of the enclosed ventilated type, in which case of course the rated output as for open running is somewhat reduced. The motors are constructed with either squirrel-cage rotors, wound rotors with slip rings, or wound rotors with slip rings with mechanically operated brush raising gear and short-circuiting device. Anyone applying to the Union Electric Company for list No. 1007 would have it sent him by return. This list gives full particulars of the Union polyphase machines, together with suitable starting apparatus.

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Equipment Buyers' Finance.

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(Abridged.)

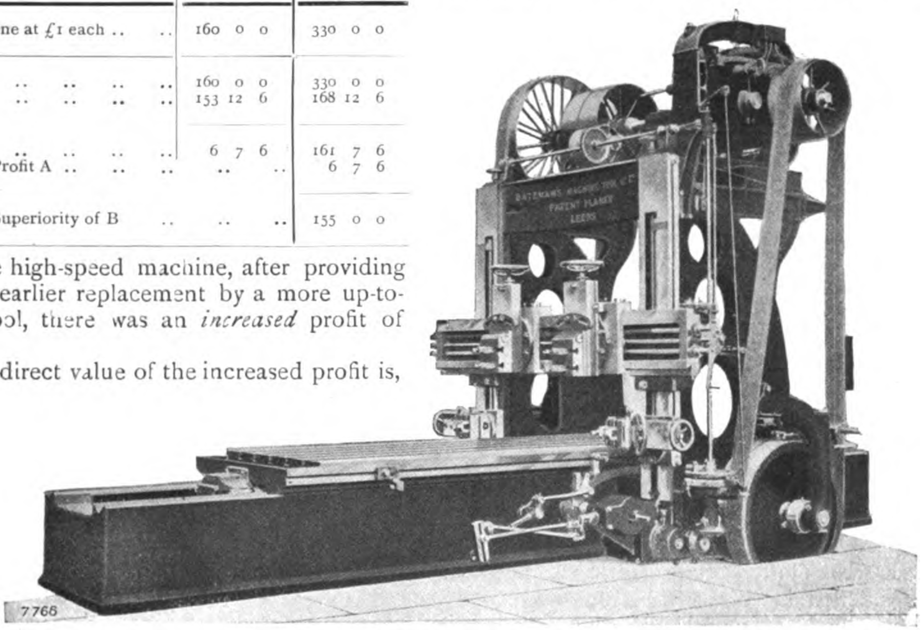
ONE of the most noticeable features of modern engineering finance is the "rule of thumb" way in which many orders are placed for tools. It is so easy to pay a few hundred pounds for mere salesmanship—tools of approximately equal capacity commanding widely different prices—that some system of guarantee appears to be more and more a thing of necessity. A mere guarantee to replace free of cost any part which may fail during the first year or two's working does not nearly meet modern requirements. As an evidence of this a case of planing may be cited. A certain piece of work which had been done under best conditions was debited to costings at £1 for machine rent or "oncost." A new quick planer heavily designed to ensure equally good workmanship and using high-speed steels, did the same work in a little under half the time—inclusive of "setting." What was the relative value of the machines? Assuming the same pieces of work were debited to costings at the same rates, their relative values were approximately as follows (column A refers to the old planer; column B to the high-speed planer):—

	A.			B.		
	£	s.	d.	£	s.	d.
First Cost	240	0	0	280	0	0
Floorage	2	12	6	2	12	6
Depreciation 10% Repairs 5% Interest 5%	48	0	0	56	0	0
Power 10h.p.				35	0	0
Power 8h.p.	28	0	0			
Wage	75	0	0	75	0	0
Working Cost	153	12	6	168	12	6
Pieces done at £1 each	160	0	0	330	0	0
Earned	160	0	0	330	0	0
Cost	153	12	6	168	12	6
Profit	6	7	6	161	7	6
Profit A				6	7	6
Superiority of B				155	0	0

On the high-speed machine, after providing for an earlier replacement by a more up-to-date tool, there was an *increased* profit of £155.

The direct value of the increased profit is, as shown, some £155, but its *indirect* value can hardly be estimated. For instance, the securing of contracts is greatly assisted by the more rapid execution of orders, by the possession of a margin which allows a "cut" to be made in bad times, and the disastrous losses attendant on slackness averted. Such considerations cannot be reduced to £ s. d. unfortunately, though it is very probable that they are far more valuable than the £155 above referred to.

Difficulties arise in the consideration of these reciprocating tools which have an "idle" or "return" stroke, because, unless a standard of production is arrived at, personal judgment becomes the only means of making comparisons. One of the chief difficulties is the great difference in time loss at the ends of the strokes. The formulæ recently compiled by Mr. R. W. Wilson meet these difficulties satisfactorily, for they take full account of these losses, and ignore the "geared-speeds" which "have proved to be worse than useless as a basis for calculating the relative efficiency" of reciprocating tools. By taking note of the time taken to make a given number of "cycles" (one work stroke, plus one idle stroke), the amount of *work done* per 1d. of wage and expenses can be calculated with reasonable precision. Methods



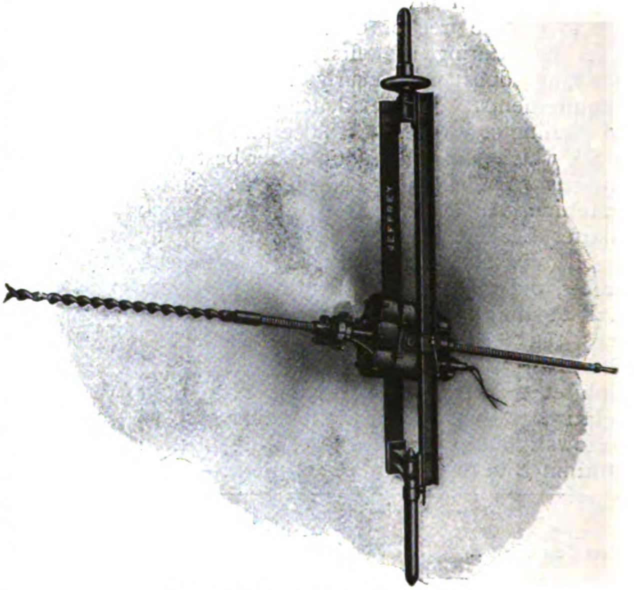
A 60in. by 60in. by 12ft. Bateman High-Speed Planer, cutting at 20ft., 35ft., and 50ft. per minute and returning at 160ft., Fitted with Bateman Patent Sliding Rack for Eliminating Shock and with Patent Flywheels for Rapid Reversing and Power Economy.

based on "geared-speeds" will give disappointment, because the mere increasing of geared-speeds without some arrangement for suppressing the correspondingly increased time loss at reversal will be nullified by those greater reversal losses, and the consequent increased power consumption.

Reciprocating tools should therefore be guaranteed as to their "cycle" times, and a comparative account prepared on similar lines to that shown.

Under ordinary circumstances the result will be entirely in favour of high-speed tools.

Messrs. Batemans Machine Tool Company, Ltd., Flax Mill Estate, near Leeds, have acted as pioneers in the guaranteeing of planing machines by cycle times. Doubtless it is the remarkable speeds attained by the use of their patents that has enabled them to take up their present enviable position in this regard.



New Type Electric Rock Drill.

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Electric Mining Drill.

The new rotary drill placed on the market by Messrs. John Davis & Son, Ltd., Derby is said to mark a new epoch, drilling in harder materials than has hitherto been possible with a rotary machine. It is suitable for use with rock, ironstone, coal, &c., and it will interest mining engineers, whose experience with rotary rock drills has not been of the happiest, to know that in this case the makers guarantee the drill, with proper usage, to withstand any duty it is called upon to perform: that if the drill point will stand up against its work, the power behind it will take care of itself.

The motor armature spindle is hollow, through which the drill feed-screw passes. By this means a well-balanced drill is provided, as hitherto the motor was necessarily above, below, or on one side of the feed-screw. The gearing has also been remodelled in this drill; a pinion of twenty-five teeth surrounds the hollow armature shaft, and this engages above and below with two driven wheels of uniform size, viz., 65 teeth. Mounted on the same shafts with the 65-tooth gears are the pinions of the second reduction set of gearing. These pinions engage the gear which drives the feed-screw. The gear wheels are accessible, and one of the features obtained in the design is the ease by which the gears may be varied.

It will be seen by the figures which follow that the speed of the drill bit may be varied from 106 to 310 revolutions per minute, and the forward feed or rate of cutting may be varied from 10.6in. per minute up to 62in. per minute, with a variety of sixteen combinations. It is thus possible to select the most suitable gearing, not only for rate of cutting but also for the speed of rotation, to suit almost any degree of hardness of material.

The drill is supplied in two standard forms:—Slow speed: 106r.p.m., letter A, with ten threads per inch of feed screw letter H, making a feed of 10.6in. per minute; and standard speed: 224r.p.m., letter C, with six threads per inch of feed screw letter F, making a feed of 37.4in. per minute. The following table shows the different rates of forward feed at different revolutions of the feed bar, with different threads of the feed screw, and the gearing for the drill can be furnished in any of the combinations:—

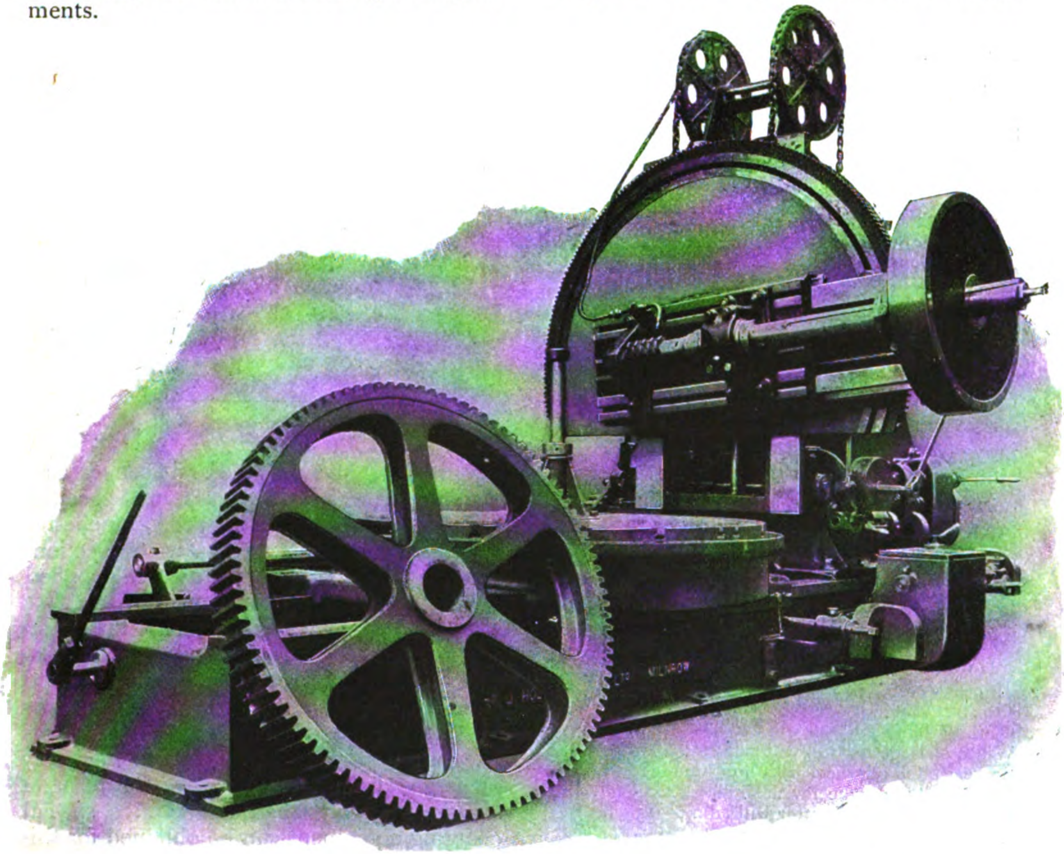
	Descriptive Letter.	A	B	C	D
	Rev. of Feed Screw per Minute.	106	167	224	310
Descriptive Letter.	Acme Threads per Inch of the Feed Screw.	Forward Feed per Minute (inches).			
E	5	21.2	33.5	44.75	62.0
F	6	17.9	27.8	37.4	51.6
G	8	13.25	20.9	28.0	38.8
H	10	10.6	16.7	22.4	31.0

The weight of the drill complete suitable for 6ft. seam working is 288lb. Each drill is provided with 50ft. of flexible concentric cable, with two insulated terminal sockets. The cable is highly insulated and braided and then leather covered. The usual equipment of augers is one each 2ft., 4ft., and 6ft. long, either 1¾in. or 2in. diameter, but these may be varied according to requirements.

Universal Gear Cutter.

THE machine shown on this page is by Messrs. John Holroyd & Co., Ltd., Milnrow, and is designed for cutting the teeth of spur, spiral, and worm wheels. Spur gears may be cut by a cutter in the form of a worm hob; spur and spiral gears may be cut by a single cutter; worm wheels may be cut by a sliding taper hob or by a single pointed tool. The work is bolted by the rim to brackets (which are secured to the table) and is centred by a mandril held in a bracket bolted to the centre of the table. This method of fixing gives the greatest rigidity, as the work is supported just under the cutter where it is required.

When cutting spurs with hob cutter the dividing change wheels are set to give the work the correct relative rotation to the cutter. The cutter head is swivelled to bring the threads of the hob to a vertical



A 10FT. GEAR HOBBING MACHINE BUILT FOR THE ADMIRALTY BY JOHN HOLROYD & CO., LTD.

straight line and the work set so as to cut the teeth the correct depth. The cutter head then feeds down the blank, the feed being automatically stopped by tapping the drop-out worm box.

When cutting spurs with single cutter the cutter head is set horizontal, the dividing change wheels being stopped by withdrawing the clutch at back. The change wheels are then set so that one revolution of the bottom change wheel shaft gives the correct change to the work. On the bottom change wheel shaft there is a disc with one notch into which a plunger is fitted; this plunger is withdrawn by foot lever when the tooth is finished, and the shaft revolved until the plunger again engages with notch. The worm wheel which is driven from worm on dividing shaft is disengaged by clutch, and the feed is now driven by the belt pulleys at back. The work is set to cut the correct depth as before.

When cutting spirals with single cutter the head is swivelled to the correct angle and the change feed gears are set to give the work the necessary movement due to the spiral of the teeth as the cutter feeds down. The dividing, setting to depth, and feed driving, are the same as when cutting spurs with single cutter.

When cutting worm wheels with taper hob or single pointed tool the cutter head is set horizontal, the work set to cut the correct depth, and the hob moved back until it just clears the work. The dividing change wheels are set to give the work and hob the relative rotation, and the differential change wheels are set so as to give the work the necessary extra movement as the cutter feeds along. The clutch in upright is set to give the cutter head the cross movement, and the cutter slides tangentially across the work and produces a tooth of the highest order of accuracy.

Worm wheels with the axis of worm at irregular angles to axis of worm wheel may be cut by swivelling the cutter head.

The principal dimensions of the machine illustrated are :—

Diam. of largest wheel will cut—10ft.
Width of largest wheel will cut—14in.
Largest pitch of wheel with hob—2in. cir. P.
Largest pitch of wheel with single cutter—4in. cir. P.
Largest diameter of cutter will admit—15$\frac{1}{2}$in.
Diam. of cutter spindle—6in.
Cone pulley—28-24-20-16-6$\frac{1}{4}$ wide.
Purchase of driving gear—45 to 1 and 10 to 1.
Spindle speeds (8 changes)—3 to 44r.p.m.
Down feed of cutter head per rev. of table for hobbing spurs and spirals (8 changes)—$\frac{1}{12}$in. to $\frac{1}{170}$in.
Down feed of cutter head per rev. of cutter for cutting spurs and spirals with single cutter (8 changes)—$\frac{1}{8}$in. to $\frac{1}{120}$in.
Cross feed of cutter head per rev. of table for cutting worm wheels (8 changes)—$\frac{1}{12}$in. to $\frac{1}{170}$in.
Diam. of working surface of table—7ft.
Index worm wheel—180T., 1$\frac{3}{8}$P., D.T. worm.
Change shaft pulleys—24in. dia., 6$\frac{1}{2}$ belt.
Speed of countershaft—250r.p.m.
Floor space occupied—21ft. 6in. by 14ft. 6in.
Approximate weight—30 tons.

◆

The "Thomson" Pocket Lamp.

THERE have been many types of electric pocket and hand lamps put on the market from time to time, but the best that could be said of most was that they were interesting novelties and they were looked upon as such. But of late years there has arisen a considerable demand for a compact, portable electric lamp, and to meet this there are lamps to be had which are in every way efficient and serviceable from the commercial standpoint. The "Thomson" pocket lamp, for instance, is used by police, fire-brigades, watchmen, meter inspectors, &c.; the makers, Messrs. L. E. Wilson & Co., Manchester, report that this lamp has been in regular use since last June by the Manchester Corporation officials for meter inspection, and that the original lamps as then supplied are in use to-day.

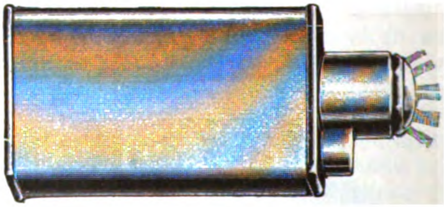


FIG. 1. THE "THOMSON" POCKET LAMP.

The lamp weighs 9oz. and fits the waistcoat pocket. A specially designed accumulator is contained in a small nickel-plated case measuring 3$\frac{1}{4}$in. by 1$\frac{3}{4}$in., and is probably the most efficient accumulator of its size on the market. It can be conveniently recharged from the ordinary electric light circuit at a very small cost, and a special charging equipment can be obtained for this purpose.

One charge will give from four to six hours'

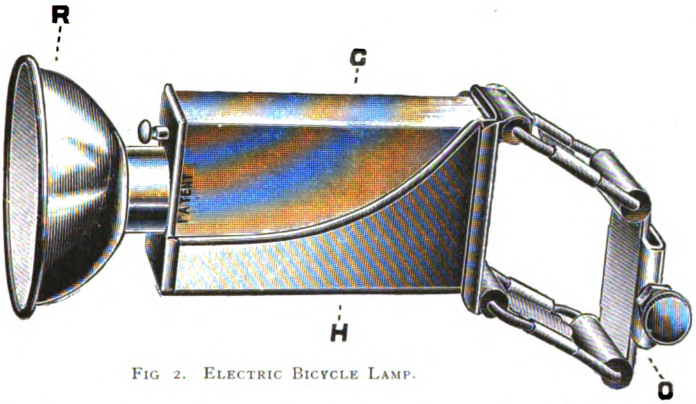


Fig 2. Electric Bicycle Lamp.

continuous light, and as for ordinary purposes the light would be intermittently used it is possible to obtain a considerable life of usefulness from one charge When the lamp loses its brilliancy and assumes a yellow colour the accumulator should be changed or re-charged at once. The lamp is supplied with a removable bull's-eye cap, attached to which is a smaller thimble which provides the necessary protection for the switch-handle when the lamp is in transit or when carried in the pocket. The switch is fitted in the most convenient place for every use and will light the lamp continuously or flash it at the will of the user.

Ruby and yellow caps for photographic dark-room use can be obtained.

The lamp may be carried in the pocket and used by cyclists and motorists as an auxiliary to the ordinary oil or acetylene lamp or it may be fixed in a special lamp case and used as a cycle lamp. It gives a greater and whiter light than the ordinary oil lamp, and is much more convenient, as it cannot be extinguished by wind. A spare battery cell (in a box) can be carried in the tool bag. The lamp is of special service for the inspection of all parts of the motor-car, and there is no risk of fire.

The illustration Fig. 1 shows the standard form of the lamp fitted with bull's-eye lens. Its adaptation as a bicycle lamp is shown in Fig. 2. It is important to note that the lamp uses a secondary battery, which of course has an indefinite life if ordinary care be taken to keep it moist and regularly charged up. It is further to be noted that, should accident or neglect necessitate a new battery, its cost is merely 1s. 6d.

* * *

Electrical Accessories.

Messrs. Ward & Goldstone, Sampson Works, Manchester, have recently issued a complete catalogue of their many specialities, which they advise will be sent to any interested reader. This firm's works are divided into two distinct departments, one for the manufacture of wires and cables, &c., and the other department for the manufacture of electrical sundries, switchboards, main switches and general supplies for electric light and power purposes. The Editor of The Electrical Magazine recently had the opportunity of visiting these works, and found them exceptionally well equipped and run on most modern lines.

The "Vitro" patent iron-clad fuse, Fig. 1,

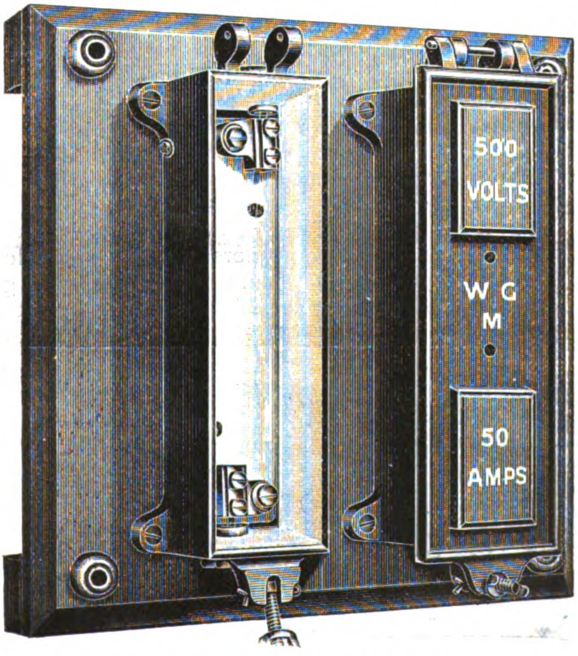


Fig. 1. The "Vitro" Iron-clad Fuse.

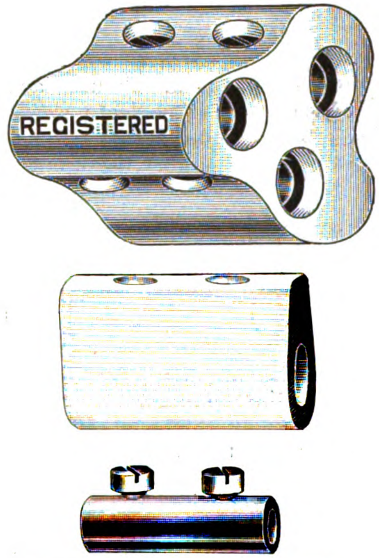


Fig. 2. "Indispenso" Connectors.

is worthy of particular note and is especially suitable for power work. The exceptional advantage of this iron-clad fuse or cut-out is that the case, instead of being lined as is usual with asbestos, is lined with a vitreous enamel which is melted into the iron at an intense heat and gives practically a surface coating of real porcelain. The disadvantages of asbestos, owing to its tendency to absorb moisture, are well known, and this vitreous enamelling entirely overcomes leakage troubles and provides in addition a perfect insulator suitable even for 500-volt circuits.

For this service the makers claim that the "Vitro" type of fuses can be used with the utmost confidence.

The second illustration shows a very useful line of cable connectors which is called the "Indispenso" connector. This consists of a substantial straight-through connector enclosed in china which enables joints for temporary or permanent work to be made rapidly without the necessity of soldering the conductors and taping the joints. These articles are made with one, two, and three ways. The immense saving in time and efficiency of the joint given by their use is very apparent.

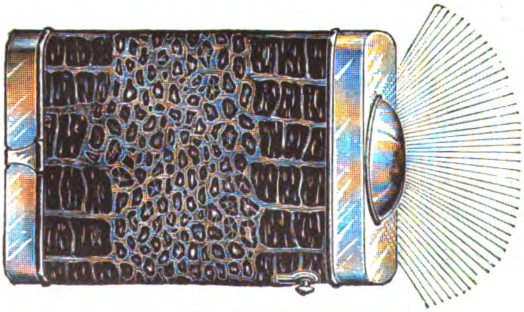


Fig. 3. The "Multum" Pocket Lamp.

The "Multum" Pocket Lamp.

Messrs. Ward & Goldstone have introduced a pocket electric lamp known as the "Multum" pocket lamp, which exhibits several novel and important features. This lamp will burn continuously for ten hours at a time, and gives a brilliant white light. The bulb is of the metal filament type, and the accumulator is of quite a special kind. In the first place it is perfectly dry and there is no acid whatever in its make-up. It can be charged innumerable times, and before the lamp was placed on the market it is claimed by the makers that the accumulators were given the most stringent tests with the best results. The size of the lamp is such that it fits comfortably in the waistcoat pocket whilst its weight is not more than six ounces.

The lamp has met with great favour by central station engineers who are supplying it to their meter inspectors, and in spite of the antipathy of gas engineers for anything electric, even they are using it also for meter-reading service.

The lamp is also being widely used by mining officials, doctors, detectives, boiler inspectors, and in fact it would seem that a lamp of this description is likely to be useful to everybody for some purpose or other. It is interesting to know that the lamp fitting and the accumulator have also been adapted for an electric cycle lamp which is meeting with very great favour amongst cyclists generally.

At the time of our visit to the makers' works it is interesting to note that we were impressed with the merits of the "Multum" pocket lamp, which certainly appeared to uphold the makers' claims on its behalf.

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BELGIAN MINING and ELECTRICAL ENGINEER, with good knowledge of English and German, proposes his services as Projecting Engineer of an Electrical firm or for Superintending an Electrical Plant. Moderate terms. Full particulars on application. Address, P.C.R., 49, Poste Restante, Verviers, Belgium.

(52nd Issue.)

The Electrical Magazine.

FOUNDED AND EDITED BY
THEO. FEILDEN.

VOL. IX. No. 5. LONDON. MAY 15th, 1908.

The World's Electric Progress.

Electricity in Iron and Steel Works.

WE feel sure that readers will welcome our continuing the story of the uses of electricity in iron and steel works. There is so very much to be gathered in the way of electrical engineering from the study of the hundreds of problems which have to be faced in the equipment and handling of modern iron and steel making plant, that, whether the individual reader be brought daily into touch with such plants, or whether he view the work done therein as being outside his workaday interests, he can always with profit to himself follow the steps of progress made in this great field of industrial electricity.

It was, indeed, due to the appreciation so universally accorded our last number, and also as following suggestions by many readers, that we were prompted to go further into the special subject. It has been our endeavour in this and last month's number, which together form the third of our "Industrial Series," to produce a thoroughly practical treatise of the subject which should be of the greatest worth to the large majority of our readers, and it is with gratification that we now acknowledge the many appreciative comments which followed the appearance of the April section of our special Iron and Steel number and also the assistance so freely rendered by iron and steel works engineers, electrical engineers and manufacturers, who almost without exception took the greatest interest in the projected special iron and steel issues of this journal.

We have in mind the preparation of other very important special issues of THE ELECTRICAL MAGAZINE to appear in the near future, particulars of which will be put before our readers in due course.

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The Electrical Exhibition.

THE preliminary work in connection with the Electrical Exhibition to be held in Manchester, during October, proceeds apace. Plans of the great hall, which is being specially erected for the purpose of the exhibition, rates for space, and all details necessary for the guidance of prospective exhibitors are now available. Already there has been a good deal of space allotted to leading firms, and it would seem that the success of the exhibition is assured. The organisers point out that applications for positions are treated in order of receipt, and it rests with interested firms to give the question their immediate attention.

As a business centre Manchester is unrivalled, and the reputation which the city enjoys as to the thoroughness with which it handles any scheme of commercial enterprise should prompt electrical manufacturers to take advantage of the great opportunities afforded by this exhibition. From the reports which reach us and the remarkable progress made thus early in its organization, the forthcoming exhibition shows promise of being the most important ever instituted for the electrical industry.

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The Industrial Prospect.

The general trade depression which pervades the country will inevitably be reflected in the records of the electrical manufacturing concerns. Whilst it is not to be expected that the result will be in any way comparable with the dire distress which now prevails in the shipbuilding and dependent industries, and of which we have had so very many other examples of recent years in the great iron, coal and textile trades—the electrical manufacturer is bound to suffer to a greater or less extent according to the nature of his products; he has, however, the great advantage in such hard times that electrical plant and goods are needed in all trades and for practically every process of business and everyday life. The returns of many electrical firms and power engineering companies have lately proved good reading; increased profits have been the rule. It is of course very true that the electrical industry only feels the effect of the vagaries of general trade after an interval. The boom in the trade of the country such as we enjoyed until within the past twelve months or so is reflected in the good reports of the electrical industry now appearing, but many of our leading firms are already feeling the reaction and have entered the period of stress produced by the labour troubles and cessation of work in the shipyards. It is hardly within our province to discuss the ethicsof the dispute in question, but it would seem that having in view the causes and conditions to which the trouble is attributable, there is little hope in sight for any early improvement. It therefore devolves upon the electrical manufacturer to conserve his fighting strength; as to just how he shall do this depends upon the class of his manufactures and the general present condition of his work and finances.

◆

Gas versus Tungsten Electric Lamps.

The following figures are given by our contemporary *The Electrical World*; they are likely to be of particular interest in view of the rapidly extending use of the metallic filament lamp. A chemist's shop was formerly lighted by twenty-four 8c.p. carbon filament lamps in ceiling receptacles, requiring 711 watts and yielding for 1000 hours an average candle power of less than 180. This installation was replaced by three 3-burner gas arcs, consuming gas at 5s. 10d. per 1000 cubic feet. The cost of gas for 1000 hours was thus £12 17s., and adding to this 30s. for maintenance, the total cost for 1000 hours was £14 7s. The tungsten installation now in use consists of twelve 40-watt lamps in ceiling receptacles, these taking 437 watts and each giving a light averaging considerably over 32c.p. The rate for the current supply is 4d. per kw. hour, making a cost per 1000 hours of £7 5s. 8d. for energy, and adding the cost of the lamps—£3 15s.—makes the total cost £11. Tests covering 570 hours of burning under voltages varying by 5 per cent. from the normal during two-thirds of the time, show that tungsten lamps will stand such variations and maintain their candle-power.

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READERS SHOULD KNOW

that owing to the Great Demand only a Few Copies of the Special Iron and Steel Number (April issue) of "The Electrical Magazine" are still available.

[For particulars as to Contents, &c., see Advertisement page 26.]

ELECTRICITY IN IRON AND STEEL WORKS.

THE ELECTRICAL EQUIPMENT OF THE CARGO FLEET IRON COMPANY'S WORKS.

* * *

THE use of electric motors is becoming more and more general in industrial operations, but nowhere are they conquering ground more rapidly than in the iron and steel industries. The electric motor with its rugged simplicity is peculiarly adapted for use in shops where the general conditions are such as those to be met with in iron and steel works, these conditions being—the all-pervading presence of coal and other dust, work of a rough and heavy nature, and unskilled labour.

One of the best examples of the large part played by electricity in modern iron and steel manufacture is that afforded by the combined iron and steel works of the Cargo Fleet Iron Company, at Cargo Fleet, Middlesbrough.

For several years this company had been employed in the manufacture of pig iron only, until 1905 when a most complete remodelling of the old plant and installation of new plant was effected in order to enable the firm to convert the whole of its output of pig iron into structural steel. This transformation has been most satisfactorily accomplished, and several hundred tons of steel are now being made every week, electricity playing a very large part in its production. Blast-furnace gas, steam, hydraulic, coke-oven and producer gas power are also largely used.

The whole equipment of the works is of the most up-to-date and complete nature, advantage being taken of the latest improvements in the highest grades of machinery existing in the principal steel-manufacturing countries, notably in Germany and America, the steel and iron making plant having been supplied principally by these two countries. The combination of blast-furnace and steel plant on one site is probably the first in Great Britain and has so far proved to be entirely satisfactory.

The works lie right in the heart of a big industrial district providing a large market right at its doors for the Company's products. The Company is also very advantageously situated as regards transport facilities, the works being in direct connection with the North Eastern Railway. In addition also to the splendid railway facilities possessed by the Company they have an extensive frontage on the mouth of the Tees and at present have a wharf some 300ft. long at which they can load up their products into deep-sea craft for transport to all parts of the world. Supplies of the principal raw materials are obtained from within a radius of twenty miles, iron ore and limestone being obtained from property owned and worked by the Company. The ironstone mines are at Liverton, and the limestone quarry is at Mickleton. The supply of iron

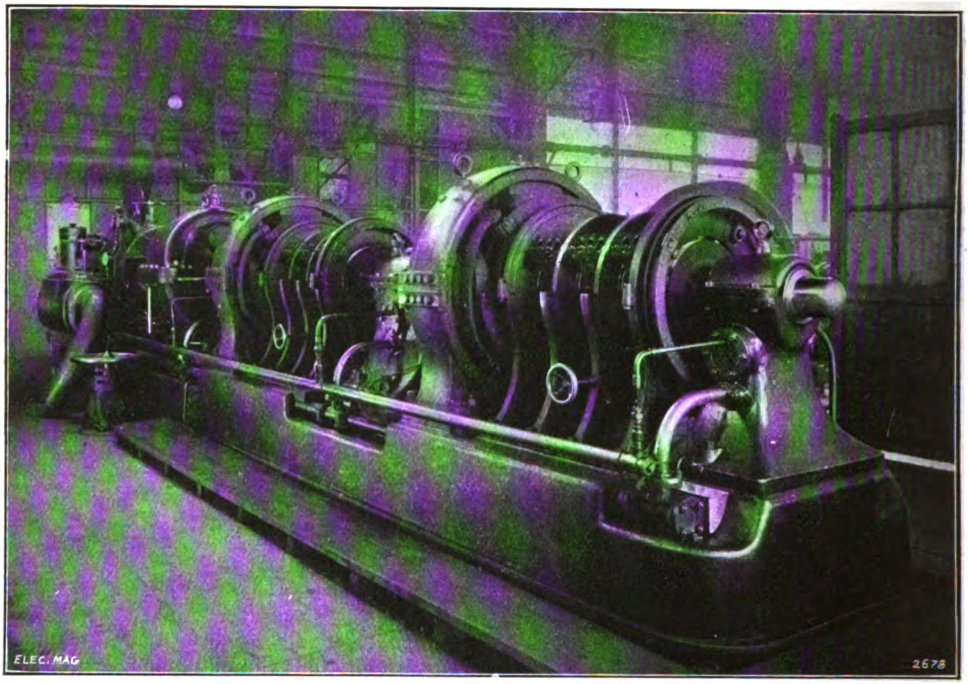


FIG. 1. WESTINGHOUSE DIRECT-CURRENT TURBO-GENERATOR; 750KW., 220 VOLTS. CARGO FLEET IRON COMPANY.

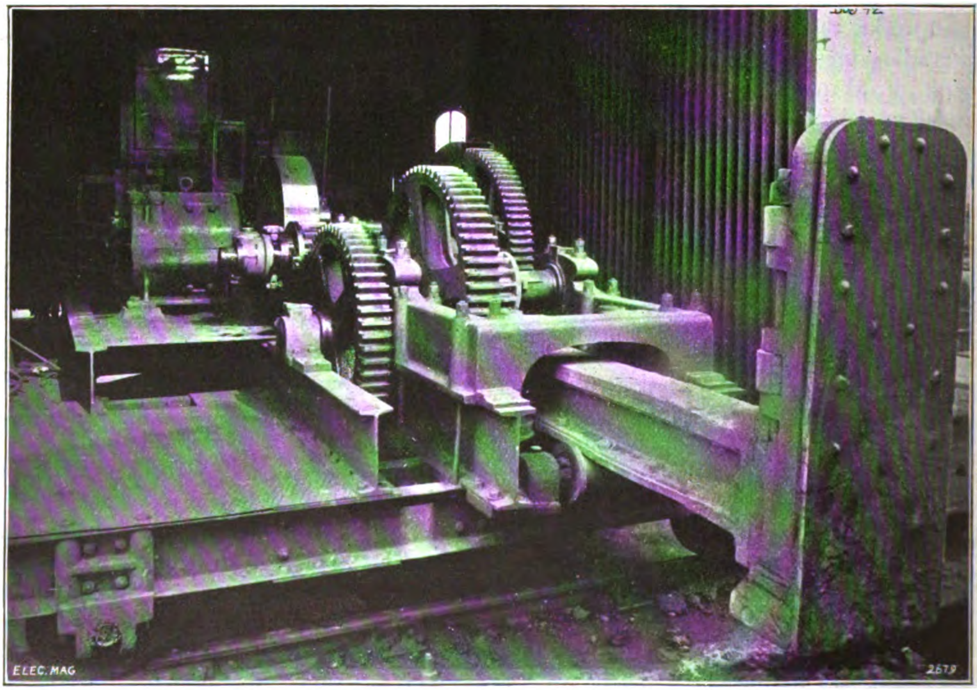


FIG. 2. ELECTRICALLY DRIVEN COKE-OVEN RAM. CARGO FLEET IRON COMPANY.

ore, it is estimated, will last for some ninety years at the present rate of consumption, *i.e.*, 7000 tons per week.

The electrical equipment of the works is exceedingly comprehensive and includes generating plant of an aggregate capacity of 3300kw. and numerous motors aggregating to over 4000h.p., the large majority of which were supplied by the British Westinghouse Company.

The power house contains a variety of prime movers, these consisting of one vertical compound steam engine, one British Westinghouse (Fig. 1), and one Richardsons Westgarth steam turbine, two Premier gas engines operating on coke-oven gas, and two gas engines using blast-furnace gas. The generators consist respectively of one 350kw., two 750kw., two 300kw., and two 375kw., 220-volt direct-current machines. The power house is spanned by a 40-ton travelling crane (by Messrs. Broadbents) fitted with four Westinghouse series-wound motors.

Coal is brought into the works on railway trucks, and these are drawn by an electric haulage gear, driven by a 100h.p. motor, up an incline on to a gantry running along the back of the furnaces, from which trucks can run on inclines to all parts of the works. The coal trucks pass from the top of this gantry to the screening and washing plants, and from the latter to the disintegrators. From the disintegrators the powdered coal is conveyed to the coke-oven coal stores by a Robin belt-conveyor. These coal stores are situated in the centre of two rows of Kopper coke-ovens, each row containing fifty ovens. Below the coal stores is a space for receiving a Baroper coal-dust compressor into which a certain quantity of powdered coal is run from the stores above and compressed into a block the same size as the inside of a coke oven. The block of compressed coal dust is next carried along the front of the ovens on a pair of rails and pushed into one of the ovens by a charging apparatus running on the same pair of rails. On receiving the coal, the doors of the oven are put on and sealed up with fireclay preparatory to the coking process. The washing, disintegrating, conveyor, compressing and charging plant are all worked electrically, the coal-washing plant using motors, one of 140h.p. and another of 10h.p., the washing water pump being driven by a motor of 80h.p. The disintegrator is operated by a 50h.p., and the belt conveyor by a 25h.p. motor. Each compressor box, of which there are three, is driven by a 35h.p. Westinghouse railway type motor, the two charging boxes being also operated by motors similar size and type.

The coal remains in the Kopper ovens for some 30 hours or more, and is there reduced to coke, the furnaces being of the regenerative type, the gas yielded by the roasting coal serving to heat the ovens. This method is a great advance on the old method of coke making in bee-hive ovens as carried on in Great Britain until a few years ago and which has now been almost entirely superseded on the Continent, but which is still largely used in Great Britain. The system at Cargo Fleet is by means of airtight ovens or retorts, these yielding a far greater output of coke than the old bee hive type, and in addition enabling many valuable chemical by-products and a large proportion of the gas produced during the coking operation to be saved. At the end of the coking period the coke is pushed out at the back of the oven by an electric ram (see Fig. 2) entering the front of the oven and driving the incandescent coke before it. The coke is cooled and broken up into convenient size as it emerges from the oven on to the coking bench, and is afterwards taken away from the bench by electrically operated coke cars, to either the blast furnace or to the stock bins as may be required. These coke cars, of which there are four, are each operated by a 35h.p. Westinghouse railway-type motor, which controls all the movements of a car. The Kopper ovens give an increased output of 10 per cent. in excess of the old bee-hive method, and effect a saving by the use of the gas and the sale of by-products of something like £20,000 per annum. The coke-oven gas is almost identical with town's gas, and the by-products, such as tar, sulphate of ammonia, &c., are extracted from it in the usual way, some of the purified gas, as previously mentioned, being used in the coking process, the rest being led to a gas holder for supplying two of the gas engines in the power house, and for various other purposes as hereafter described.

The manufacture of pig-iron is carried on in a couple of blast furnaces, located at about the centre of the site. These are supplied with calcined ore, limestone, and coke from two large hoppers or bins close at hand, which discharge into the skip of the Brown

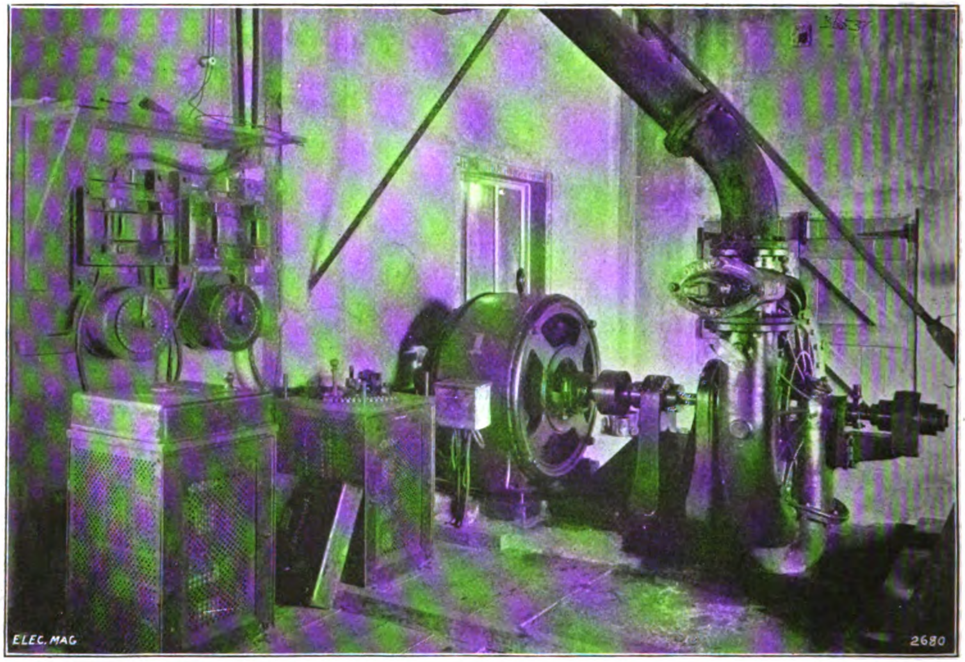


FIG. 3. CENTRIFUGAL PUMPING SETS DIRECT-COUPLED TO WESTINGHOUSE MOTORS. CARGO FLEET IRON COMPANY.

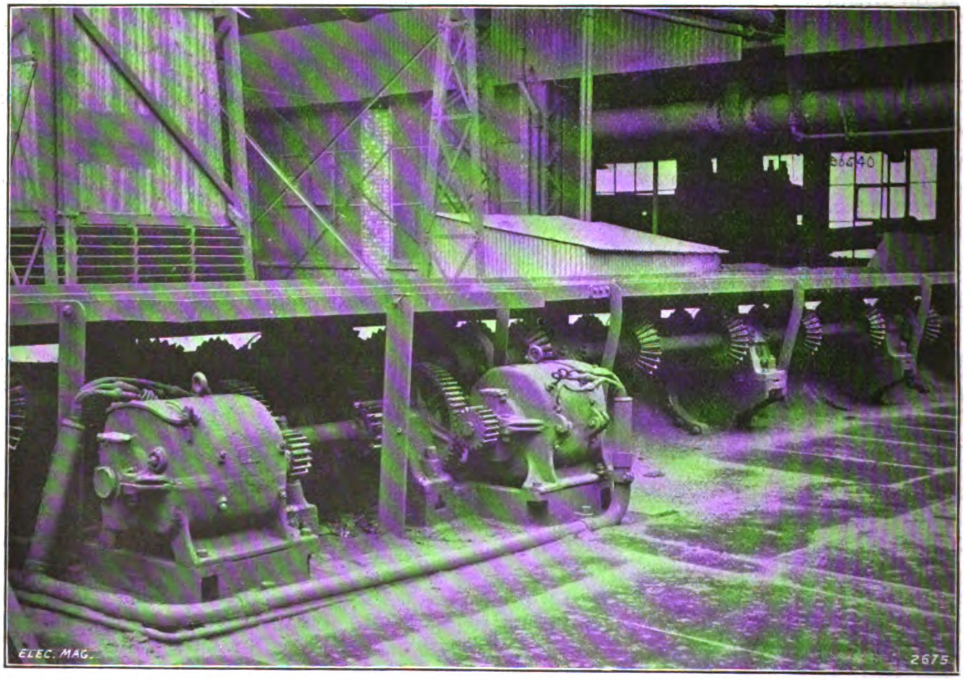


FIG. 4. ELECTRICALLY-DRIVEN LIVE ROLLERS FEEDING BLOOM SHEARS. CARGO FLEET IRON COMPANY.

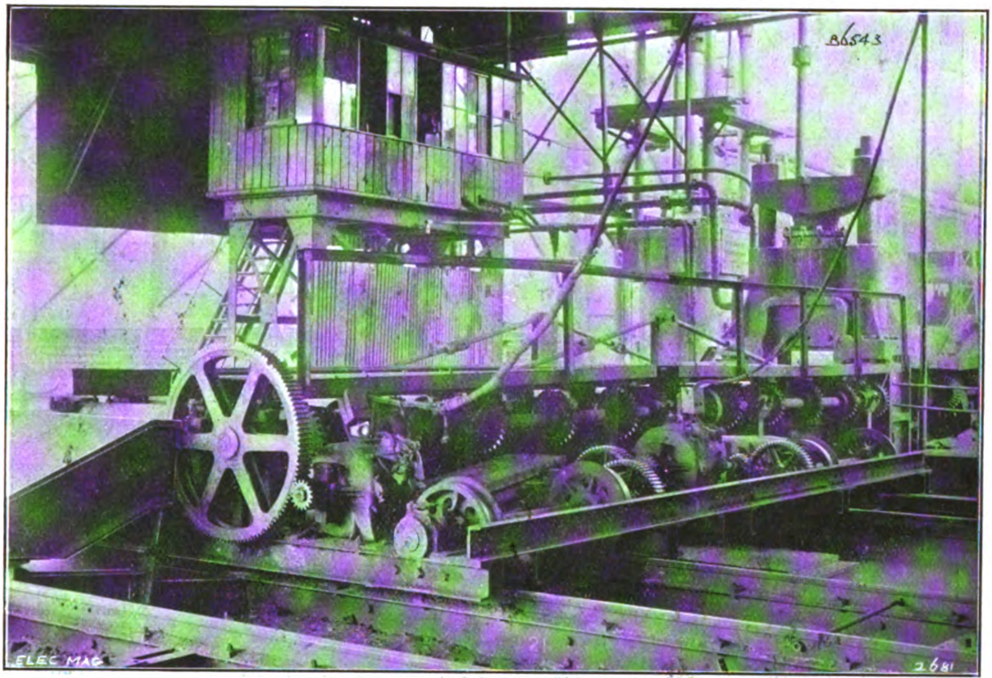


FIG. 5. TRANSFER TABLE DRIVEN BY WESTINGHOUSE MOTORS. CARGO FLEET IRON COMPANY.

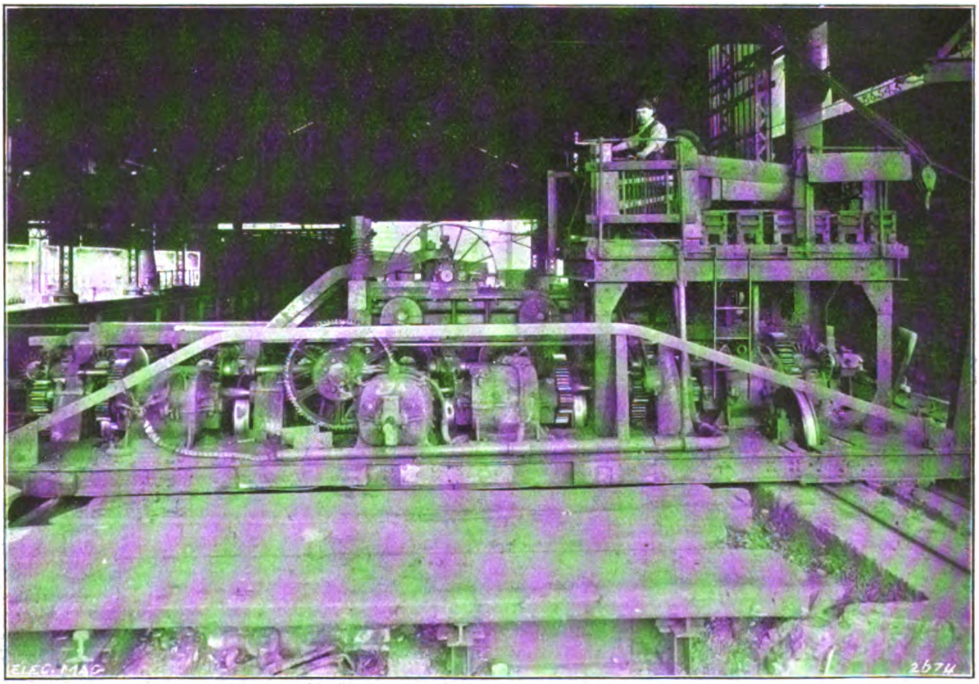


FIG. 6. COLLINS CHARGING MACHINE OPERATED BY FIVE WESTINGHOUSE MOTORS. CARGO FLEET IRON COMPANY.

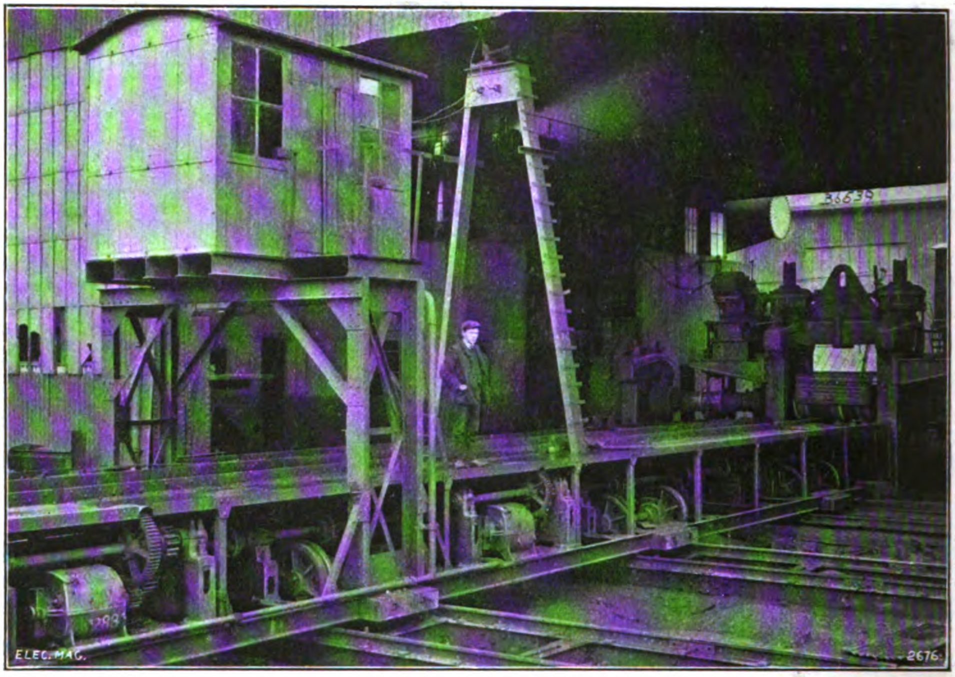


FIG. 7. TRAVELLING TABLES DRIVEN BY ELECTRIC MOTORS. CARGO FLEET IRON COMPANY.

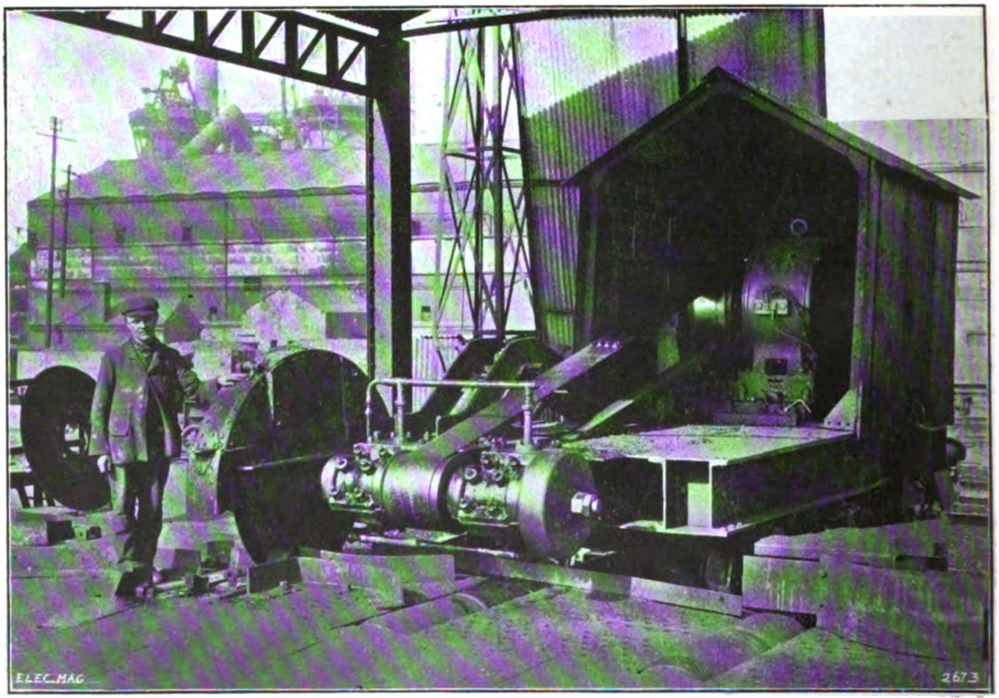


FIG. 8. HOT SAW DRIVEN BY 100H.P. WESTINGHOUSE MOTOR. CARGO FLEET IRON COMPANY.

hoist-charging equipment by means of endless belts, the various ingredients being automatically weighed during the passage from the bin to the blast furnace. The calcined iron and limestone are delivered to these bins by means of the gantry previously mentioned. The whole process of charging the furnaces is done mechanically, no men being required at the top of the furnaces. The original blast-furnace plant consisted of five furnaces, each 75ft. high, and with 24ft. bosh, and blown by five blowing engines, the blast being heated in twelve Cowper stoves. These furnaces have been replaced by the present pair, each of which is 90ft. high, with 11½ft. hearth, and 21ft. bosh, designed for a maximum output of 1400 tons per week.

The blowing engines are a notable feature of the blast-furnace plant and consist of seven Cockerill gas engines, of Messrs. Richardsons Westgarth & Co's. manufacture. Cooling water for the pistons and cylinder jackets of these gas engines is supplied from a tank which is in its turn supplied from a Morrison cooling tower, the water being pumped from the engines to the tower by means of two Gwynne centrifugal pumps (Fig. 3), each driven by a 70h.p. motor; the cooling water is pumped through the cooling tower and to the supply tank by four pumps, driven by 32h.p. compound-wound motors. Each engine is fitted with an electrically worked "barring" arrangement operated in each case by a 10h.p. series-wound motor. The engine-house is spanned by an electrically operated 20 ton three-motor crane by Booth Bros., of Rodley.

The gas from the blast-furnaces, when the latter are in full blast, amounts to about 63,000 cubic feet per minute, and is used partly in the blowing gas-engines and partly in the Cowper stoves for heating the blast, being, however, thoroughly cleansed before being used. This latter operation is accomplished by means of ingenious arrangements of the piping, and by gas washers, the washing plant consisting of three Theisen washers, each of which is operated by a 150h.p. compound-wound motor. Two of these washers are capable of dealing with all the gas from both the furnaces, the third being installed as a stand-by. The gas goes into the washers at a temperature of from 300deg. F. to 400deg. F., and with two to four grammes of dust per cubic metre, and comes out at a temperature of 70deg. with only .016 to .02 grammes of solid matter per cubic metre, and is then suitable for the gas engines. This is believed to be the first instance in the history of iron making in which all the blast furnace gas has been freed from dust before being used.

The process of making steel is a very interesting one, the system adopted for its manufacture being the Talbot continuous process, and the plant erected the largest of this type yet installed in Great Britain. The continuous system of making steel by the Talbot process is as follows:—

At the commencement of a run, steel scrap is put into the furnace; this is melted with the necessary reagents, and metal from the mixer is poured into a hot metal ladle and carried to the ingot moulds, the remainder being then over-oxidized by the addition of suitable materials, and then further metal is poured in from the mixer.

The actual process at the Cargo Fleet Iron Works is as follows:—

The iron from the blast furnaces is run into 20-ton and 25-ton hot-metal ladles carried on standard gauge trucks, which are then hauled by steam locomotives to the steel plant. On arriving close to the two metal mixers, each of which is of 150 tons capacity and fired by gas from the coke ovens, the metal is poured into the mixer and some of the sulphur and silicon eliminated. On the charging side of the plant is a 40-ton Broadbent crane fitted with six Westinghouse series-wound motors, the total capacity amounting to 175h.p. From the mixers the metal is carried in a 20-ton ladle by means of the aforesaid crane to the Talbot furnaces, of which there are three, each being of 175 tons capacity (supplied by Messrs. Richardsons Westgarth). On the pouring side of the furnaces there are two 75-ton cranes each equipped with Westinghouse series motors; these cranes carry the ladles to the ingot moulds, and pour the metal into moulds of from 3 to 5 tons capacity. The ingots after being cast are taken on special cars, hauled by steam locomotives, to the stripping house, where the moulds are stripped off and the ingots put direct into the soaking pit until required in the rolling mill. The slag from the steel furnaces is run out at the back into slag bogies, and is taken away to a special basic slag plant, which has been put down in order to crush the slag for agricultural purposes. The gas for firing the steel furnaces is made in ten Talbot producers, from which the gas is led

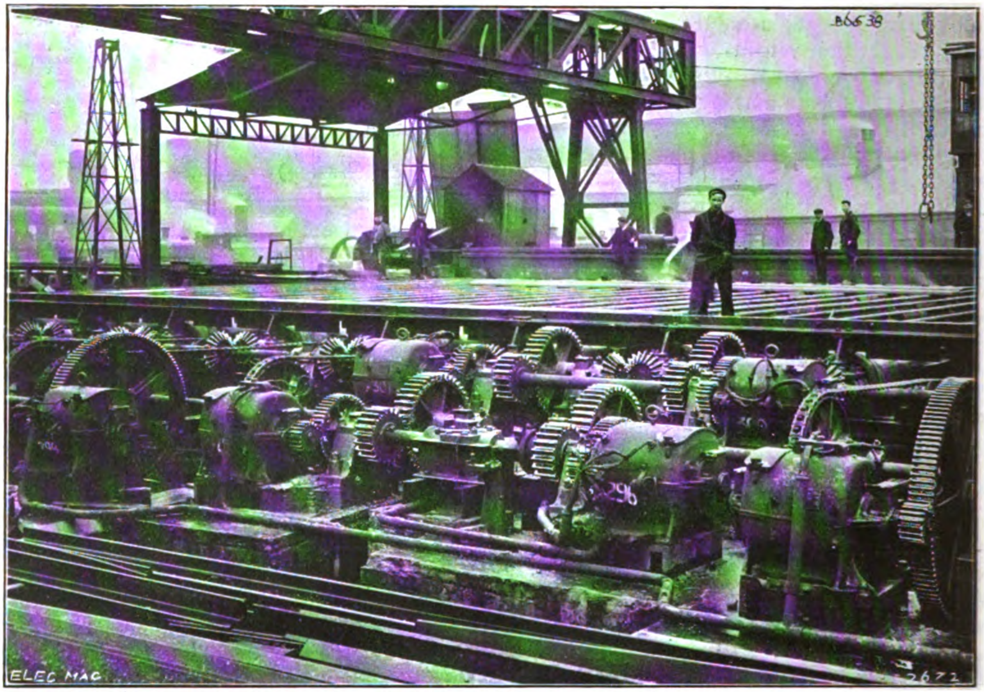


FIG. 9. HOT BANK: ROLLS AND SKID GEAR ELECTRICALLY DRIVEN. CARGO FLEET IRON COMPANY.

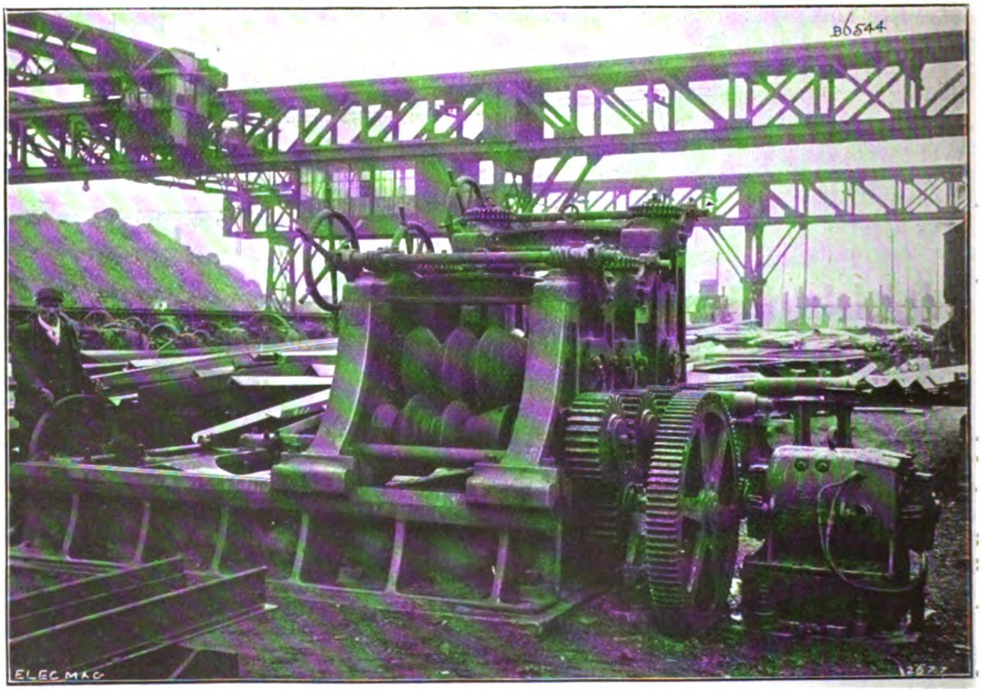


FIG. 10. BEAM OR GIRDER STRAIGHTENING MACHINE DRIVEN BY WESTINGHOUSE MOTORS.
CARGO FLEET IRON COMPANY.

to the furnaces through large regenerators in much the same manner as in a Siemens' furnace.

The next process in the manufacture of the structural steel is that of cogging. This is done by a cogging mill having 40in. centres, and 8ft 6in. rolls, and driven by an 18,000h.p. three cyclinder vertical-compound condensing engine by Richardsons-Westgarth. The soaking pits are gas fired, surplus gas from the Talbot furnaces being used for this purpose, and are spanned by a 15-ton Broadbent crane, and a mast crane of the Stuckenholtz type, the former crane being equipped with four Westinghouse motors. From the soaking pits the reheated ingots are lifted by the 15-ton crane and placed on a mechanical chair for conveyance to the cogging mill. After being cogged down to the required size the ingots are fed by further live roller gear (Fig. 4) to the bloom shears, where they are cut up into the required lengths. The live roller gear at the back and front of the mill is operated by four Westinghouse railway-type motors of 55h.p. capacity to each set of cogging rolls, the only people required in the mill being a man and two boys for the control of the live roller gear and one man for the cogging-mill engine. From the bloom shears the blooms are transferred to the Collins charger by a shear transfer table (Fig. 5), and are taken into either a gas-fired heating furnace, where they are reheated preparatory to the finishing rolling process, or direct to the mill as the case may be. The Collins charger (Fig. 6) is operated by four 20h.p. and one 10h p. Westinghouse motors. The cogging mill is spanned by a 40-ton Ransome and Rapier crane, operated by three Westinghouse motors, for the changing of rolls and other operations in connection with the cogging plant.

From the reheating furnaces the blooms go to the finishing mill. This mill consists of four sets of rolls driven by a steam engine of the same size and type as that driving the cogging mill. The reheated bloom is placed on a live-roller table and carried to the first pair of rolls, and is then passed in succession through the four pairs of rolls by means of travelling tables on both sides (Fig. 7). From the last pair the piece is carried forward by means of an extended roller rack to the hot saw or shears as may be desired.

The hot saw is driven by a 100h.p. shunt-wound Westinghouse motor and is illustrated in Fig. 8, the live-roller gear is also electrically operated by means of 20h.p. tramway type series-wound motors, these also being of Westinghouse make. The finishing mill is equipped with a 60-ton electrically operated crane, fitted with series-wound 22h.p. and 20h.p. motors for the main and auxiliary hoists, and 15h.p. and 6h.p. motors for the longitudinal and cross traverse respectively. Under this crane are also the roll-turning shop and the roll stores, so that when changes of rolls and repairs are necessary, they can be very easily carried out with its aid.

Beyond the finishing mill is a hot bank for cooling purposes, measuring some 100ft. by 52ft., from which the finished sections are fed by live-roller gear through the straightening machines to the shears, where they are cut into convenient and standard lengths. The hot bank as illustrated in Fig. 9 is operated by eight Westinghouse motors, each of 20h.p. capacity; four of these are on the live rolls and four on the skid gear. The angle and beam straightening machines (Fig. 10) are electrically driven, the former by means of a 55h.p. motor and the latter by means of a Westinghouse 30h.p. shunt-wound motor.

The beam or girder straightening machine is for straightening beams and girders up to 24in. by 7½in., the live roller gear on either side being operated by a 20h.p. series-wound motor. The head-stock for straightening different sizes of beams is run in or out by means of a 5h.p. series motor. The hot bank and straightening gear are spanned by a couple of 10-ton gantry cranes, each equipped with three Westinghouse crane-type motors. The rail bank is equipped with two double-sided and one single-sided straighteners by Messrs. Craig and Donald, each of which is electrically driven by a Westinghouse motor. In the case of the larger machines a 20h.p. motor is used, the single-sided machine having a 15h.p. motor. In addition there are three ending machines and five drilling machines, all driven by motors of British Westinghouse make.

The water for use throughout the works is obtained from the town, and a considerable quantity from the Tees, the water being pumped from the latter by means of two Mather & Platt turbine pumps operated by 70h.p. motors.

THE RELIABILITY OF LARGE GAS ENGINES AND THEIR USE IN IRON AND STEEL WORKS.

LEONARD ANDREWS, A.M.I.C.E., M.I.E.E.

* * *

It is now becoming universally recognised that the large modern gas engine is the most efficient converter of heat units into mechanical units it has yet been possible to obtain. Recent authenticated tests showing thermal efficiencies as high as 30 per cent. have been obtained with gas engines of between 1000h.p. and 2000h.p., whereas an efficiency of 20 per cent. in steam plants of much greater output is still considered remarkable. In spite of this very great advantage, many engineers hesitate to use large gas engines even under conditions where the load factor is so high that economy in fuel is of paramount importance, and this scepticism is invariably traceable to rumours that have been freely circulated that such high economy can only be obtained at the sacrifice of reliability.

Now, whilst economy of fuel is an important factor of the successful working of practically every industry, reliability is much more important. In view, therefore, of the fact that the design of the large internal combustion engine does present difficulties quite different to those met with in steam engine design, coupled with the fact that some of the large gas engine installations which have been put down have proved failures, one cannot blame those engineers who hesitate to sink large sums of money in ventures so surrounded by such danger signals.

Discounted by such apparent disadvantages, one can but wonder that the large gas engine has made such remarkable progress, as it undoubtedly has done, during the past few years, and one is particularly impressed by the fact recorded by Mr. Rheinhardt in his paper before the Iron and Steel Institute in 1906, that at that time there were no fewer than 349 engines aggregating 385,000h.p. actually at work, or on order, in German iron works and collieries alone, and that the majority of these gas engines were working continuously without any reserve.

It cannot be supposed that reliability is of less importance to German works managers than to their confrères in this country. Can it be, then, that the dangers we have heard so much about have been overrated? After visiting a number of iron works and collieries in Germany, the writer was forced to the conclusion that the latter is the true explanation. A few months ago he endeavoured to collect some authentic data from existing works with a view to forming some opinion as to what the danger of interruptions might reasonably be reckoned to be. He found, however, that it was extremely difficult to obtain much information upon this subject. It is unfortunate for those who wish to be fully informed on such matters that no records are kept of the majority of plants which run well, turning out the power required day in and day out. The author was, however, able to secure a copy of a chart recording the performance of a gas engine in one iron and steel works, which he believes may be taken as an average record of the majority of large gas engines made by first-class makers.

The engine whose performance is recorded is a 1300h.p., single-tandem, double-acting engine made by Messrs. Ehrhardt & Sehmer of Saarbrucken. It is identical with about sixty other engines that have been turned out by this firm having an aggregate output of over 72,000h.p. The chart which is reproduced in Fig. 3, page 321, records every stoppage of the engine in question for any purpose during a period of nine months, with the duration of the stop in each case. It will be noted that the majority of these stoppages occur on Sundays and holidays (shaded on the chart), and they are, of course, made for the purpose of overhauling sparking-plugs, &c. There are probably very few industries that cannot conveniently arrange for a shut-down of a few hours on, say, each alternate Sunday, and where it is essential that the supply should be absolutely continuous, this can, of course, be assured by installing a certain amount of spare plant as is usual in steam practice.

Enquiries made as to the frequency with which sparking plugs, &c., should be examined elicited the following information. Sparking plugs should be examined, if

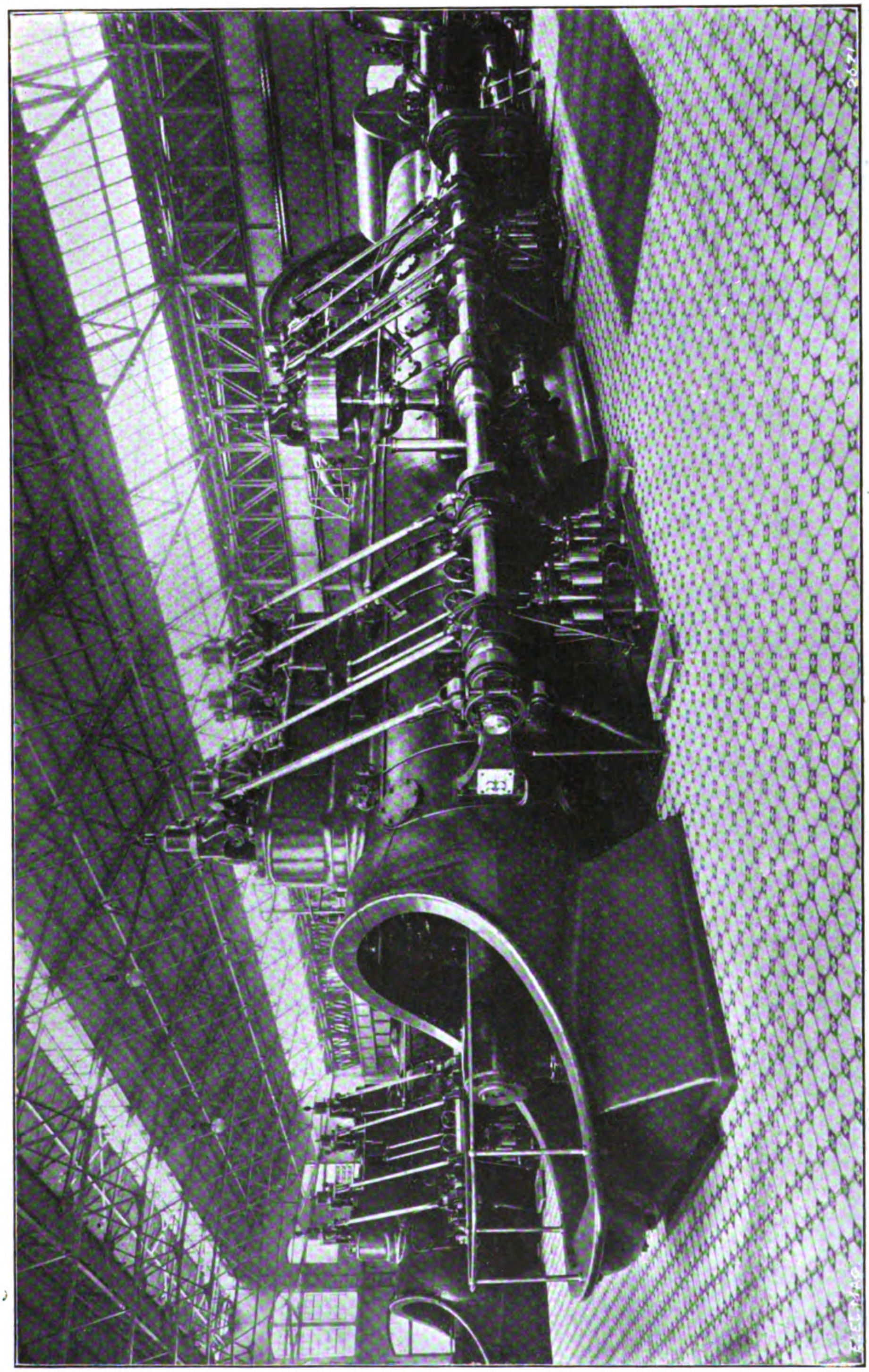


FIG. 1. TWO SINGLE-TANDEM 2200H.P. EHRHARDT & SEHMER GAS ENGINES AT THE HOESCH IRON AND STEEL WORKS.

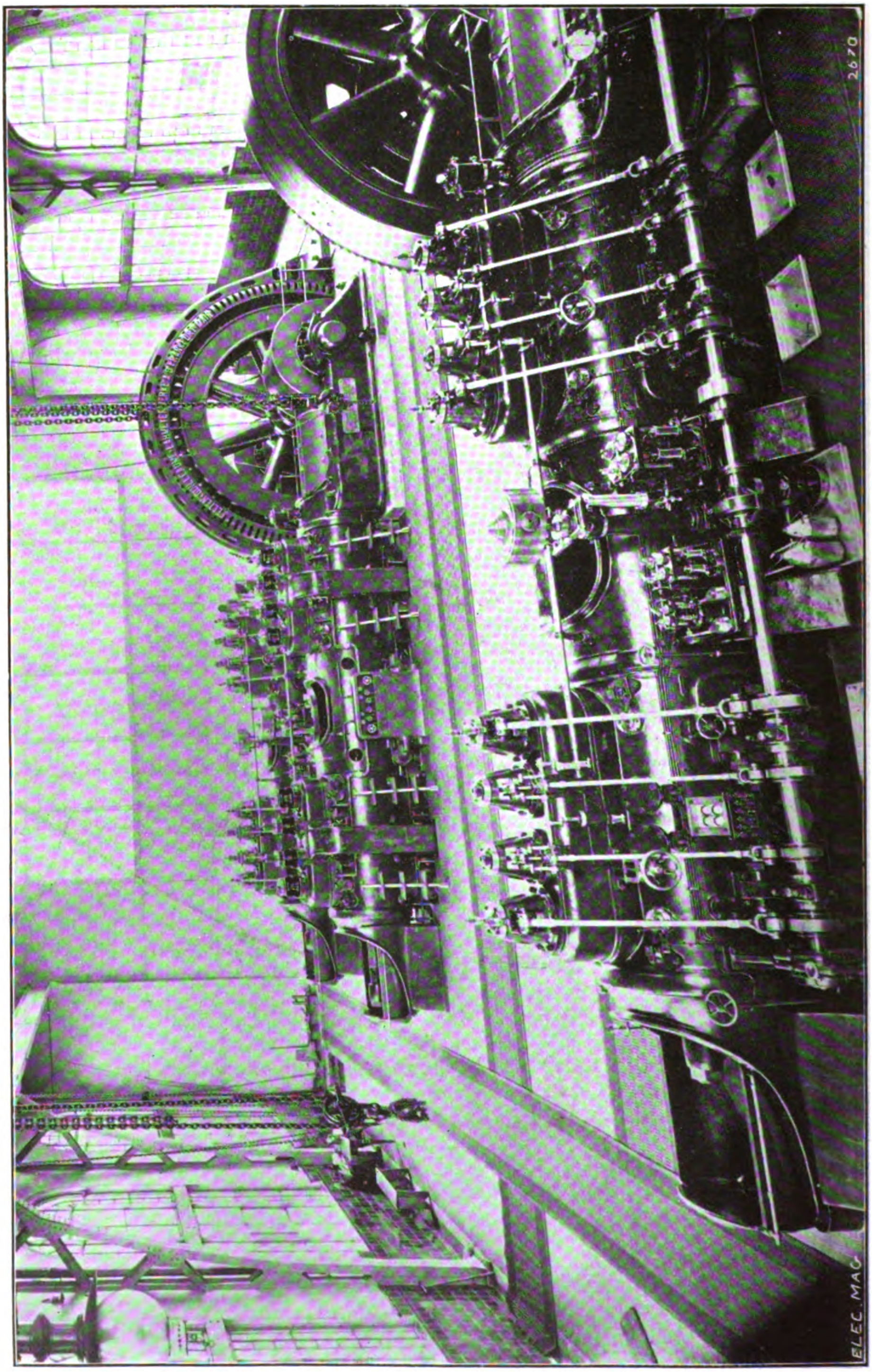


Fig. 2. First Section of the 12,000 H.P. Ehrhardt & Sehmer Gas Engine Installation at the Government Mines, Heinitz.

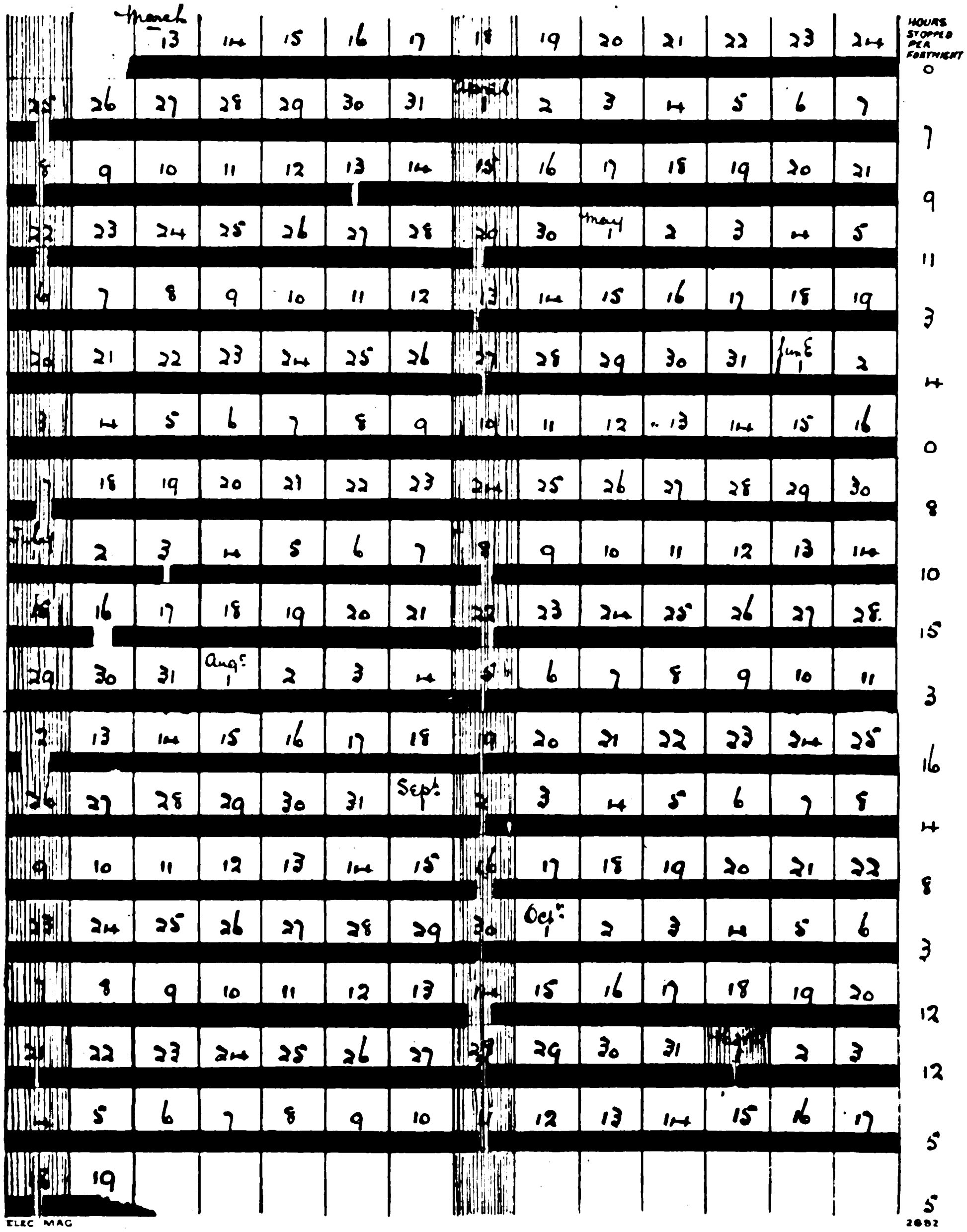


FIG. 3. CONTINUITY CHART OF A 1300H.P. EHRHARDT & SEHMER ENGINE IN AN IRON AND STEEL WORKS.

	HOURS.	PERCENTAGE OF TOTAL RUN.
TOTAL LENGTH OF RUN	6048	.. —
HOURS STOPPED (SUNDAYS AND HOLIDAYS) ..	119	.. 1.97%.
„ „ (WORKING HOURS)	16	.. .26%.

possible, every week, but will run for three weeks or a month. Several makers are now using the Lodge system of ignition, which, it is anticipated, will run for much longer periods without overhauling.

Mixing valves, where the dust is not excessive, can be safely run for eight or ten weeks without overhauling.

Cylinders, exhaust valves, and inlet valves, do not require cleaning more often than once a year. A number of cases are recorded of engines having run practically continuously for fifteen and eighteen months without being opened out.

One often hears it stated that whilst large gas engines may run satisfactorily on blast-furnace gas, trouble is bound to be experienced when working with gas of considerably higher calorific value, and containing a much higher percentage of hydrogen.

Coke-oven gas is considered one of the most difficult compositions to work upon, since it has a calorific value that often equals that of town gas, and usually contains an even greater percentage of hydrogen.

The installation at the Government mines at Heinitz, the first section of which is illustrated in Fig. 2, is run entirely on coke-oven gas and if one may judge by the extensions that have followed the original installation, the performance of these engines has been entirely satisfactory. This installation, which originally consisted of the three engines shown in Fig. 2, is now being extended and when the present extensions are completed, will have an aggregate output of approximately 12,000h.p., consisting of one single-tandem 650h.p. engine, four twin-tandem 1300h.p. engines, and two twin-tandem 3000h.p. engines.

It is often said that the labour entailed in running a gas engine station is excessive. In view of this the writer was greatly interested to note on the occasion of his first visit to the Heinitz Station that the total staff for the three engines consisted of one driver, one switchboard attendant, and one greaser. At the time of this visit the engines were driving alternating-current generators coupled in parallel and were supplying current to a varying load averaging about 75 per cent. of the capacity of the plant. The three men in question were all on their knees cleaning the engine-room floor and the plant was running by itself quite automatically. The governing was so good that there was no appreciable variation in the voltage in spite of the varying load, and there was evidence that very little synchronising current was passing between the generators.

There appears to be a general belief amongst engineers in this country that it is impossible to get satisfactory large gas engines of over 500h.p. or 600h.p Mr. Bertram Blunt in his reply to the discussion upon his note on "Electro-metallurgy" before the Engineering Conference last year said: "With regard to the unit of size for gas engines, it seems to be generally accepted that very large gas engines up to 2000h.p. or more are still in an experimental stage, whereas the smaller engines of 300kw. to 500kw. are practical machines and can be used in most industries."

It is suggested that those engineers who share this opinion should visit some of the large gas-engine installations on the Continent, and should include in their trip a visit to the very fine gas-engine installation at the Hoesch Iron and Steel Works at Dortmund, where they will see a number of large engines by different makers. They will be particularly impressed by the two 2200h.p. Ehrhardt & Sehmer single-tandem engines illustrated in Fig 1.

Through the courtesy of the Hoesch Iron and Steel Company, a large number of English visitors have had an opportunity of seeing these engines at work at different times during the past year. The characteristic of all their comments has been "it was most impressive." Many with preconceived ideas of large gas engines have gone to the works expecting to see and hear vibrating, noisy, clattering engines, and to find the engine room filled with exhaust gas fumes and the engines throwing oil all over the place to the accompaniment of violent explosions. Instead of which they have found perfectly clean, quiet, smooth-running engines that at first sight one would mistake for large horizontal slow-speed Corliss valve steam engines. It is stated that these engines have the largest output per cylinder of any gas engines that have so far been made. The output of each cylinder is 1100h.p.; thus the total output of a twin-tandem engine of this size would be 4400h.p. It is impossible, after inspecting this installation, for any engineer to retain the opinion that large gas engines are still in an experimental stage, or that they are less reliable than steam engines.

NEW RAILS FROM OLD.

QUITE a special class of work is undertaken by the English McKenna Process Company, Ltd., at Seacombe, near Birkenhead. The raw material of this steel works consists of rails worn by service or otherwise of unsuitable section. These are re-heated and rolled down to required correct sections of lighter weight. There is very much in the equipment of these Birkenhead works which will be of interest to iron and steel engineers, inasmuch as they were laid out and equipped expressly for the special McKenna process, and the complete plant is electrically driven.

The main power-generating plant consists of three turbo-alternators, each of 750kw. capacity, the three-phase current being generated at 440 volts 25 periods per second, and the speed of the sets being 1500r.p.m. The turbines are of the Willans type, supplied with steam at 165lb. per square inch at the stop-valve, and each is complete with its condensing plant as a self-contained unit. The alternators by Messrs. Siemens Brothers Dynamo Works, Ltd., have a normal rating of 750kw. at 80 per cent. power factor, but they are good for overloads up to 950kw. for one hour. They are of the rotating-field type, having the rotor wound in almost completely closed slots, the ends of the windings being carried on gun-metal core heads, and completely covered by manganese bronze rings of such proportions that no displacement of the winding could take place even with an increase of 50 per cent. above normal speed. The fixed armature has former-wound windings placed in open slots and secured in position by wooden wedges.

The load conditions of the generating plant are, of course, of a trying nature, owing to the rolling-mill service of the supply, and, as a consequence, particular precautions have been taken with the

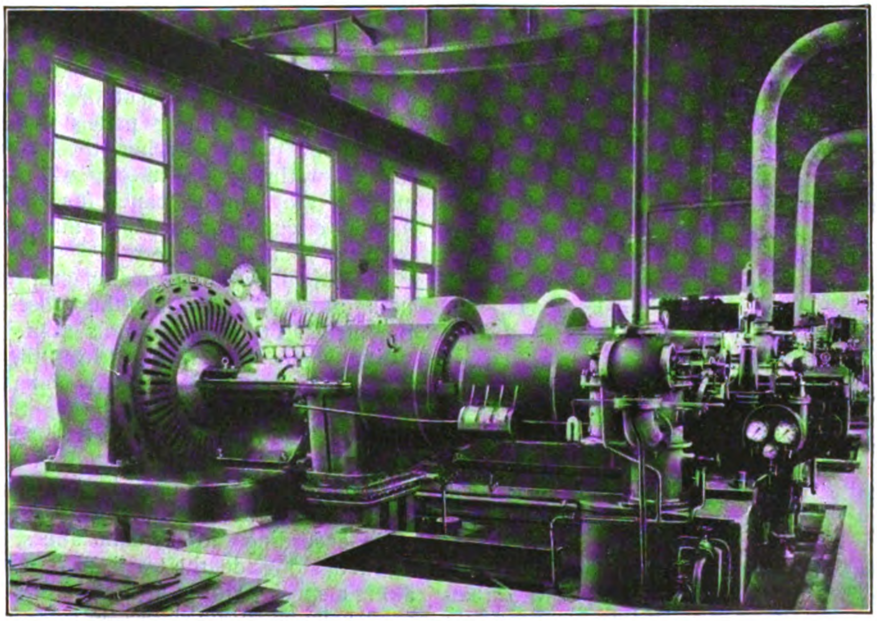


FIG. I. POWER HOUSE, SHOWING TURBO-ALTERNATORS.

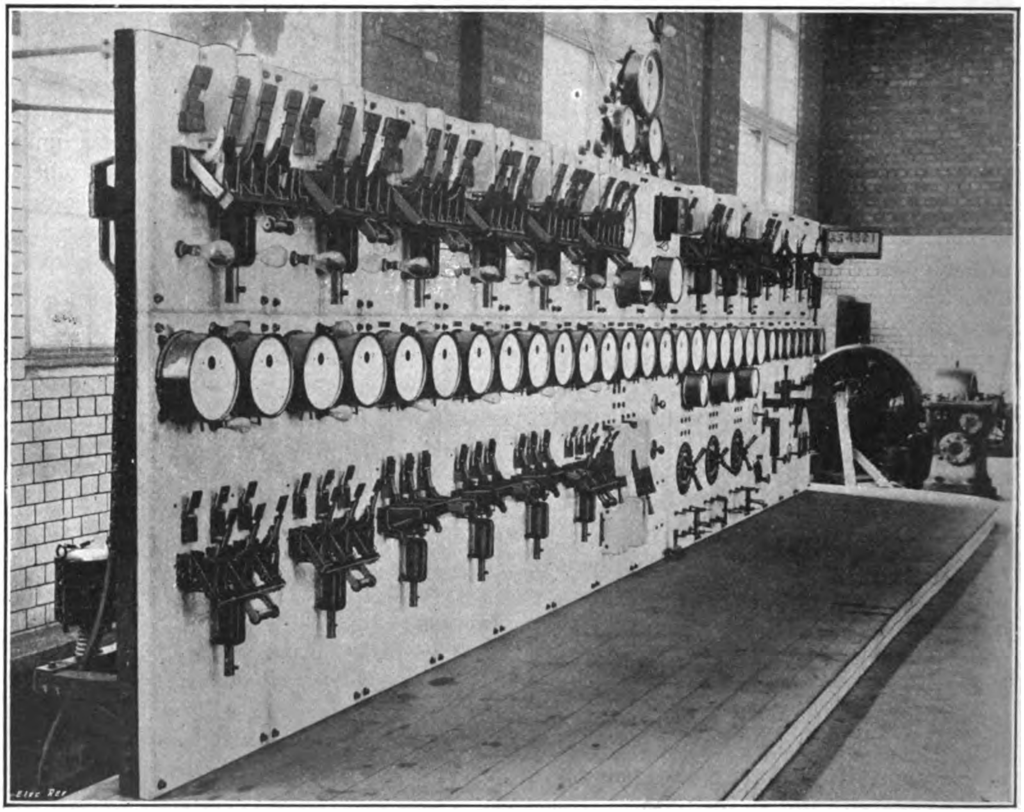


Fig. 2. Main Switchboard of Power House.

governor arrangement. An ordinary sensitive centrifugal governor of the throttle type controls the turbine speed in normal circumstances, but in addition to this there is an emergency governor which comes into play when a maximum predetermined speed has been reached and shuts off the steam supply altogether.

The exciting plant consists of two Belliss-Siemens direct-coupled 50kw. sets, the exciting pressure being 250 volts. In the power house there are also two Siemens rotary-converter sets with transformers. One of these has an output of 150kw., the other 50kw. These converters yield direct current at a pressure of 250 volts, their supply being normally used for driving the electric pumps, &c., of the condensing machinery.

The main switchboard in the power house consists of 15 white marble panels, including three main generator panels, two direct-current panels for the exciter circuits, six feeder panels, and two other panels containing apparatus for the alternating-current and direct-current slides of the rotary converters; the remaining panels include an instrument panel carrying the main ammeters, wattmeter, voltmeter switches, &c., and an arc lighting panel for the works lighting circuits supplied with direct current from the rotary converters.

Turning now to the manufacturing plant it is interesting to follow the process from the arrival of the worn rails at a railway siding, where they are lifted from the trucks by an overhead electric travelling crane fitted with three three-phase induction motors. The hoisting and travelling motions of this crane are each effected by a 30h.p. motor, the traversing being taken care of by a 5h.p. motor. The rails when unloaded are, according to circumstances, either stacked alongside the track, or they are run along a special siding and lifted direct from the trucks on to the skids.

Should a rail be badly worn there will

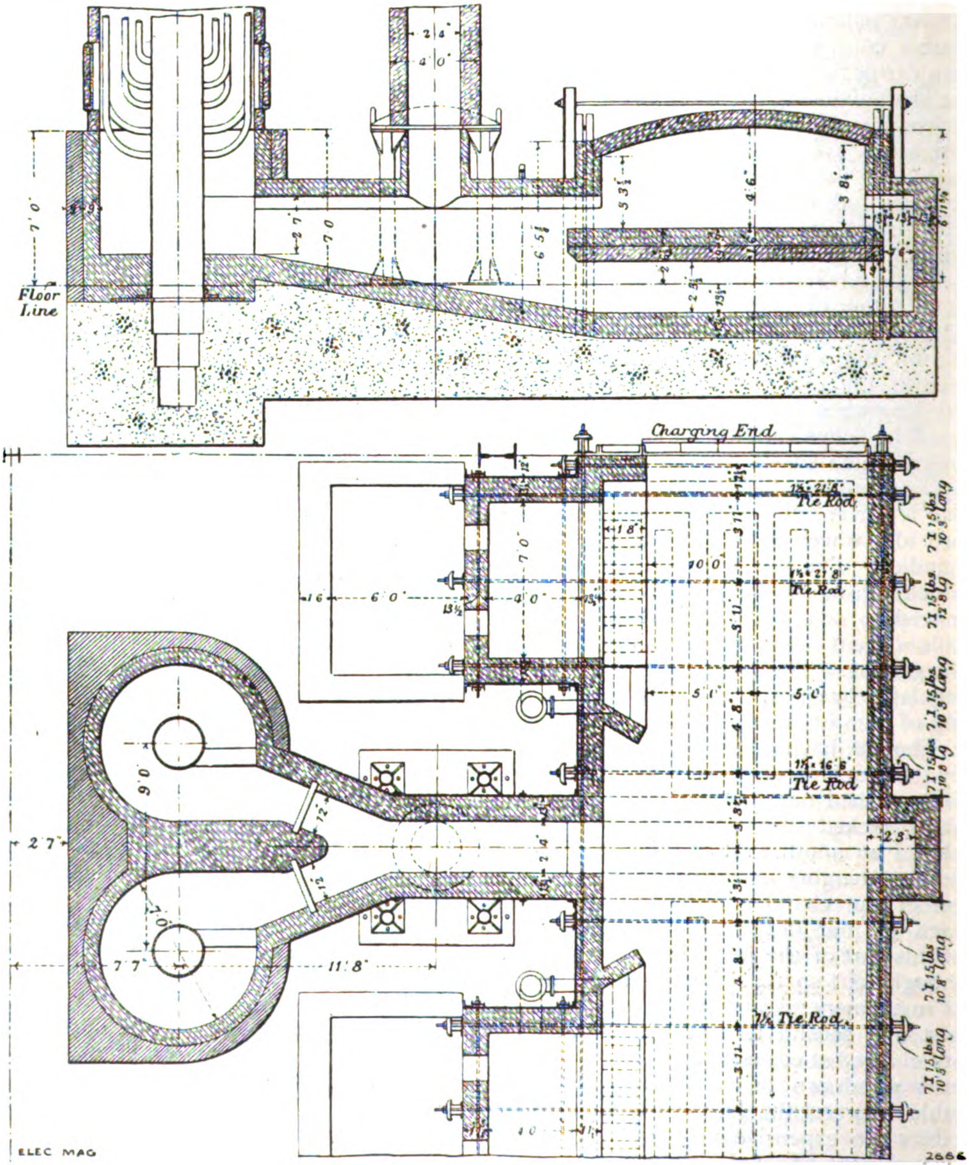
probably be a fin of metal squeezed out at one side of the head. To put the rail through the rolls in this condition would cause the fin to be folded against the head of the rail, and produce a seam. It is found advisable, therefore, to grind such fins off the rails, and for this purpose two grinding machines are installed.

The motor driving each grinder is placed independently at the end of the machine and is directly coupled to a shaft supported on two pedestals and carrying three pulleys. One of these pulleys is a narrow one and drives a double cone variable speed gear, which in turn drives through bevel and worm gearing the shaft actuating the feed rolls at each end of the machine. The other two pulleys, which are 10in. broad, are belted one to each of the grinding spindles. These spindles both run in the same direction, and each carries at one end a face grinding corundum wheel, 18in. in diameter, which can be accurately set up to the rail by a hand wheel at the other end. The feed rollers are flat, of 12in. diameter, and are inclined so that the fin of the rail is brought nearest to the face of the grinding wheel. Between the grinding wheels and feed-roller housings are small housings carrying three pairs of idle rollers which steady the rail laterally. The upper as well as the lower feed roller of each pair is driven, the drive being by means of two idle wheels geared between the roller-spindles. The idle wheels run in link-work which allows the upper feed-roller to be moved up or down to suit various sizes of rails without interfering with the centres of the gearing. The grip of the feed-rollers is regulated by springs and hand-wheels at the top of each housing.

The rail, having been ground, is delivered by the machine on to another set of skids. It is pushed out of the building along these skids, picked up by the yard crane, and placed on another set of skids opposite the furnace-charging machines. There are altogether four charging machines, one serving each of four furnaces. The arrangement of this part of the plant has been very well thought out so that the minimum amount of machinery should be necessary. The first and second furnaces from either end are charged at opposite ends, and the heated rails withdrawn on to a common transfer table between the furnaces. The transfer-tables are expensive machines, and by the arrangement adopted only two of them are required. One of them delivers the heated rails at the beginning of the roll train, and the other at two-thirds of the way down, so that rails which require very little working are handled by the latter, and consequently have only to pass through two mills.

The rail from the grinding machine is placed on the skids opposite one of the charging machines. Each charging machine is a built-up structure which travels sideways on five rails; the machine has a number of projecting bearers, which after being placed under the rails are raised, lifting the rails from the skids and so conveying them on to idle rollers on which they are pushed forward into the furnace by a bogie driven by endless chains. About half a dozen rails are generally handled at one operation, the furnace having a capacity of about twenty rails, which are heated simultaneously. The charging machine is operated for all its motions by a 25h.p. three-phase induction motor suitably geared down and furnished with clutch mechanisms actuated by means of hand levers to bring the several motions into play.

There are altogether four rail furnaces, the two which feed the roll train at the end being smaller than the others which deliver the rails farther down the train. The end furnaces have a useful floor area of about 25ft. by 10ft., while the larger ones have a floor of the same width, but 45ft. long. Both sizes are similar in general construction. Figs. 3, 4, 5 and 6 show the general form of the smaller furnaces. These are of the reverberatory type, having two grates situated on the same side and close to the ends. The air for the furnace is supplied by a motor-driven fan, delivering through the vertical pipes. The primary air passes straight down the pipes and is blown up through the fire-bars, while the secondary air is taken off by a branch, and led to the back of the hearth by a flue under the hearth. It returns to the front of the furnace by a zig-zag flue under the hearth, and becomes heated in its passage, finally escaping through ports in the face of the firebrick arch. There it meets the incompletely-burnt products of the furnace, and finishes their combustion. The products of combustion flow over the hearth, converging from each grate towards the centre of the hearth, where the gases divide, part going directly to the waste-heat boilers, and part leaving the hearth by a flue on the opposite side, making their way to the boilers by way of a passage under the centre of the hearth. The passage of the gases through either of the boilers may be shut off by a damper in the flue. These dampers are lowered if their respective boilers are to be put out of service for any reason, and the gases then escape from the main flue through the vertical shaft, the damper to which is opened for the purpose. All the vertical walls of the furnace are supported by means of buckstays, each composed of a pair of 7in. rolled joists side by side, and opposite buckstays are tied together by long bolts crossing the furnace in both directions. The uptake for the waste gases is supported by a kind of entablature resting on four cast-iron columns, to relieve the main flue of the weight. This arrangement and other features of the design are fully shown in the illustrations.

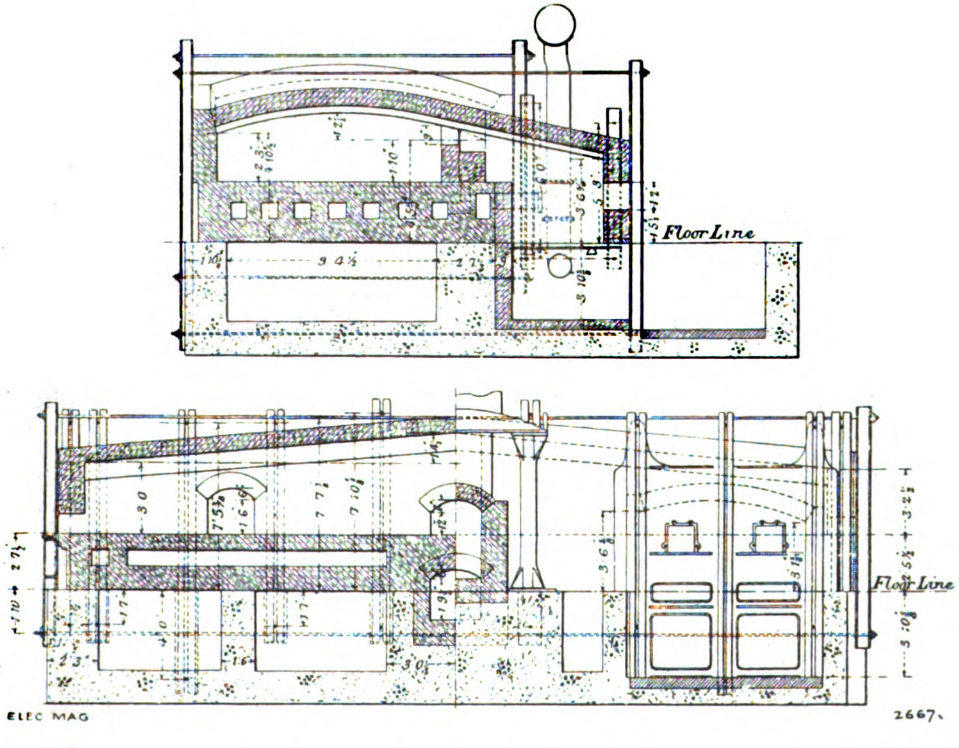


Figs. 3 and 4. Reverberatory Furnaces.

The waste-heat boilers, which utilize the high temperature of the gases passing off from the furnaces in raising steam for the machinery in the power-house, are of 250h.p. each, and altogether eight in number. They supply steam at 165lb. pressure, and work in conjunction with a bank of Babcock & Wilcox boilers in the power house. Each furnace has two boilers, but in the case of the smaller furnaces the settings are combined, and the boilers are placed close together at the end of a single flue. The boilers are of the vertical water-tube type.

The rail having been heated, the furnace doors on the discharge side are raised and the rail pulled out endways on to the transfer table. This is situated between two furnaces. The rail comes from the furnace into live rollers immediately in front of the furnace door.

The live rolls of the transfer table and the drawing-out rolls are driven by a three-phase motor geared to a shaft at the side of the table. The motors are 50h.p. for the small table and 75h.p. for the large one. The end of the driving shaft is connected to the drawing-out rolls through bevel gear. These rolls are very short and are arranged to travel longitudinally so that they may be brought in front of the rail which is to be withdrawn; this longitudinal motion is obtained by a worm and a wheel driving through a friction clutch. The drawing-out rolls deliver the rail on to the transfer table proper, its progress being helped by the action of the live rollers on the table. There are eight of these, 12in. in diameter and about 12ft. long, each independently driven by a bevel gear from the side shaft geared to the main driving motor. As soon as the rail is properly on the table, the 50h.p. motor is stopped and a $7\frac{1}{2}$h.p. three-phase motor is started. This small motor drives an independent shaft, carrying three pulleys, from each of which a drive is taken to one of the traversing dogs. These are iron fingers fixed to wire ropes, by which they are drawn across the table parallel to the end of the furnace; they are arranged to pass under a rail lying on the table on their backward stroke, but on the return stroke



Figs. 5 and 6. Reverberatory Furnaces.

they push the rail across the table on to six skids and thence on to the main-roll train.

The total length of the main-roll train is about 422ft. It contains six pair of rolls spaced at successively greater distances apart along its length in rough conformity with the successive increases in length of the rail as it passes down the train. The tables between the rolls and at both ends, altogether seven in number, are independent parts of the whole thing, and are similar to each other, except that their length increases from about 35ft. in the case of the first, to 72ft., the length of the last of the train. The beds are 4ft. 7in. wide, and are composed of a pair of 10in. channels which form the sides, and carry cast-iron plates and side angles at the top. The channels are supported on concrete piers 12ft. apart, so that the top of the bed is about 2ft. 8in. above the floor level. Every 6ft. along the bed is a live roller, 9in. in diameter, running in eye brackets bolted to the channels. The live rollers of every bed are all driven by bevel gear from a shaft running along the side of the bed, which is in turn driven by gearing from a 7½h.p. motor. Each bed is quite independent of the others, and its live rollers can be started or stopped quite independently of the others. The function of the rollers is, of course, to convey the rail from one rolling mill to the next.

Each set of main rolls is driven by its own three-phase motor, the six motors being situated in a long alley screened off from the rolling mill by a partition of galvanised iron, through which the second-motion shafts pass. A jaw-clutch on each second-motion shaft allows the rolls to be stopped independently of the motors; but these clutches are not used in the normal working of the plant. The motors are of the three-phase induction type, built by Messrs. Siemens Brothers & Co., Ltd., and work direct off the 440-volt 25 periods supply from the power house. They are each of 500h.p., and run normally at 300r.p.m., this speed being reduced in the ratio of about four to one for the rolls by large helical gear. The gearing is of 5in. pitch, and 18½in. wide on the face. The pinion is of 38.2in. pitch diameter, with twenty-four teeth, and the wheel of 12ft. 5.6in. diameter, with ninety-four teeth, both wheel and pinion being shrouded to the pitch line. The maximum torque of the motors is specified as not less than 2.75 times the full-load torque, at a constant voltage. The rotor winding is symmetrically disposed in half-closed slots, one end of each of the three sections is joined up to a neutral point, the other three ends being carried through the centre of the shaft to three copper slip-rings, from which the current is collected by carbon brushes. The motors are built to stand the violent and sudden overloads due to the nature of their work, and will carry their full load continuously for six hours without the temperature rise in any part exceeding 72deg. Fahr.

The rolls may be set in motion either by the rolls attendant or by the engineer at the switchboard in the power house. The latter usually does the starting on receipt of a signal from the rolling-mill—or, rather, he switches in an automatic starter standing near the motor required. Fig. 7 shows the diagram of connections. The automatic starter device is used for stopping as well as for starting, and consists essentially of a rheostat in circuit with the rotor winding, operated by a small motor. The motor drives a screw which causes a short-circuiting arm to travel over the resistance contacts, as shown in Fig. 8. The motor, &c., is mounted on a marble slab, at the back of which are the resistances, and the whole of the moving parts are contained in an iron-framed cupboard closed by a large glass door.

Referring to the diagram, Fig. 7, the action of the starter is as follows:—The windings marked "rotor" and "stator" are those of the motor driving the rolls; immediately to their right is the reversing switch for the stator, used in case there is any necessity of reversing the rolls. From the rotor, heavy leads run to the starting resistance S R. S and S_1 are solenoids which, when energised, actuate a reversing switch, which regulates the direct-current motor M. This motor, when running in one direction, cuts out resistance in the rotor winding, finally short-circuiting it; and when running in the other direction, inserts the resistance. It is so arranged with self-actuating switches that it cannot over-run at either end. The main cut-out, to which heavy leads run from the stator of the rolls motor, is actuated by the coil C, this coil being energised by the contactors N (whose action is dependent on the amount of current in the stator winding), or by the push-button P. Switch B controls the current in coil C; switch D is in when the cut-out is out; lamps L and L_1 are on the switchboard, and push-button P is convenient to the rolls. To start the rolls the main cut-out is put in; this closes the stator circuit, and at the same time energises solenoid S, lighting up lamp L as it does so. Motor M slowly cuts out the resistance, and finally, after short-circuiting the rotor, cuts itself and its indicating lamp out. To stop it, it is only necessary to push the button P; this, by completing the circuit through coil C, throws out the main cut-out. When this cut-out comes out, it closes switch D, energises coil S_1, at the same time lighting up lamp L_1, and, by so doing, reverses motor M, which returns the short-circuiting device to the off position. When this position is reached, the motor and lamp are automatically cut out of circuit as before.

Of course, an alternating-current motor might have been used at M in place of the direct-current motor, but the direct-current was available, which made it somewhat simpler.

After the motors of the main rolls have been started, and the heated rail placed by the transfer-table on to the live-table of the first of the main roll train, the live rollers of that table are started, and the rail carried forward by them to the first rolls. These rolls deliver the rail on to the next table, and as soon as it is there the live rollers of that table are started. The rail goes forward, and is guided by the attendant into the second rolls, which it may enter on its side. In this manner it is carried right down the roll train, the passage through the series of rolls being practically automatic and requiring the minimum of manual labour, the whole journey from the furnace through the six rolls to the final table only occupying about 45 seconds.

The rail, on leaving the rolls, is still quite hot, and is not finished with yet. At the end of the roll-train are three hot saws, which cut off the ends of the rail, and from the roll-train the rail travels into position for being cut. The distance between the first and second saw is 14ft., while the third saw is movable, and can be set at any distance from about 27ft. to 33ft. from the second. Each saw is 3ft. 6in. in diameter, driven by a 12in. belt from an overhead motor. Between the saws are live rollers at 3ft. pitch, shaped to suit the finished rail, these rollers being driven by a 10h.p. motor which is also geared to the live rollers of the last table of the main-roll train. Consequently, when this motor is started the rail travels along until brought up by a buffer-arm just beyond the third saw. It is then in front of the two end saws at least, and, if a long rail, in front of all three.

Assuming the rail to be about 44ft. long as rolled, and it is required to be 42ft. finished. The first and third saws will then be used for cutting off the ends. When the rail lies before the saws it is cramped opposite each saw by means of a system of levers and toggles. The two end saws are then traversed slowly forward on their beds by hydraulic cylinders at the back of each, and the ends of the rails are simultaneously cut off. The severed ends drop into shoots provided, and are taken out behind the saws by chain conveyers. A man on a platform well above the saws, where he is in a position to see all that is going on, controls the cutting operations.

If there is any difference in the weight or shape of the top and bottom of the rail, and often there is a very considerable difference, it is clear that the lighter part will cool first—it thus rapidly assumes

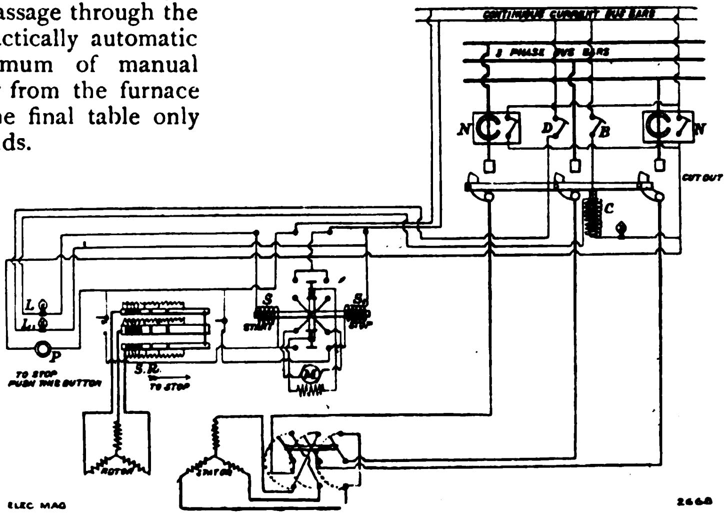


FIG. 7. STARTER CONNECTIONS OF MAIN ROLLS MOTOR.

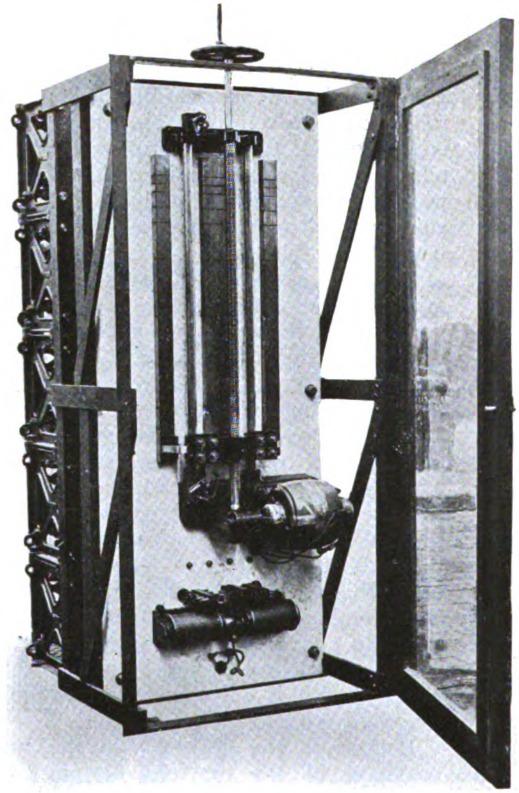


FIG. 8. STARTER FOR 500H.P. MAIN ROLLS MOTOR.

its final length, and as the slower cooling side grows cold it contracts, and pulls the whole rail round into a curved form. Obviously to ensure the rail being straight after cooling it must be given a sufficient curvature when hot in the opposite way to that in which it tends to go when cooling. The amount of initial camber required can only be found by experience, but in a 45lb. flanged rail, 40ft. long, it may be as much as 1ft. at the centre of the rail.

The rail comes from the hot saws on to the cambering machine, where it is made to pass between three staggered rolls of suitable shape geared together with their axes vertical. The front roller is fixed in position, being on the main spindle of the machine, but the two hind rollers are on swinging arms so that they can be set so as to give a greater or less curvature to the rail. The action of the cambering-machine causes the rail to travel through it, and it leaves the machine to go on the hot-bed situated close by. This is a sort of immense grid, 140ft. long and 40ft. 6in. wide, where the rails are allowed to cool. Every 10ft. down its length double joists run across it, carried on piers, and these joists support longitudinal rails spaced about 3ft. 6in. apart. The rails form the top of the hot-bed, which is 2ft. 5in. above the floor level. From the rear or incoming end of the bed three bogies run down nearly to the other end, one in the centre of the bed and one close to each side. They run on rails a foot below the top of the bed and are pulled to and fro by endless wire ropes, returning under the bed and passing round drums at the back. The bogies are driven by a 25h.p. electric motor and move simultaneously as the three driving drums are all geared to the same shaft. Each bogie has a hinged finger projecting above the level of the hot-bed, which can be depressed against the action of a weight in the forward direction, but is rigid against pressure tending to force it backwards. As the bogies come backwards, the fingers will pass under a rail lying on the hot-bed, but on their return journey the fingers push the rail down towards the other end of the bed. There the rails cool and it is interesting to watch the spasmodic jerks of the rail as it straightens itself out in cooling.

At the delivery end of the hot-bed are other motors which drive another set of bogies similar to those described. These bogies run under the cooled rails, and on returning pull them along to the end of the bed. The motors working both the pushing and pulling bogies are controlled by men on raised platforms at either end of the bed, who have a clear view of the complete bed.

It is probable that the cold rail will not have become completely straight on cooling, so it is taken from the bed to one of the straightening presses. There are four of these machines—one directly opposite the end of the bed, one on each side, and one further off. Straightening is a comparatively slow process, so that four machines are necessary to cope with the supply of rails. A conveyer at right angles to the end of the bed supplies two of the straightening presses, the rails being skidded by hand to the others, as the distance is small. The conveyer consists of a number of live rollers driven by bevel gear from a shaft running along the side. Rails destined for the most distant straightening press are carried down the full length of the conveyer and there strike against a lever. This operates a clutch on the driving shaft and causes a number of arms to rise up between the rollers of the conveyer bed, which push the rail off sideways on to a set of skids, where it remains until wanted by the man working the straightening press. Every rail not taken from the conveyor for the intermediate straightener comes on to the end and is automatically dumped as described, without the intervention of any attendant.

The straightening presses are similar in general construction to punching machines. A motor is mounted at the top of the heavy cast-iron frame of the machine and drives a rising and falling ram by means of a double reduction gear and a crank. The ram has a face slightly rounded in the longitudinal direction of the rail. The rail lies along the table of the machine under the ram, resting on two rollers 5ft. 6in. apart, and guided sideways between vertical rollers adjustable in the bed. The ram descends midway between the supporting rollers on any point of the rail determined by the attendant. The straightening process is entirely controlled by the man working the machine, who bends the rail when and where he thinks fit, judging almost entirely by his eye.

The rail, when straightened, has its ends trimmed up, and its length accurately adjusted by one of the rail-ending machines, of which there are two. The rail is measured with a gauge or tape measure, and marked to length. The end is then cramped in the box of the machine, and a revolving cutter shaves off the face of the section, the box being automatically fed forward until the cut has reached the mark. The other end of the rail is then treated in a similar manner. If the rail were a great deal too long, or a piece worth keeping had to be cut off, it would not be taken to the ending machines, but would be dealt with by the cold saw. From skids it would be slid on to a long roller-table in front of this machine and cut where required.

The cold saw is a most interesting machine. The principle on which it works is not new, but the method of cutting, for some reason or other, is not in general use, though it has been used to a considerable extent for armour-plate, &c. Broadly speaking, the machine is nothing more or less than a disc of soft-iron boiler-plate, revolving at an excessively high speed, and forced through the rail to be cut. The disc is about 50in. in diameter and $\frac{5}{16}$in. thick, mounted on a spindle driven by a 15in. belt from a 125h.p. induction motor. It runs with a surface speed of 27,500ft. per minute, and will go through a 50lb. or 60lb. rail in about 5 seconds. The saw spindle is carried in bearings in a saddle sliding vertically on the framing of the machine, and counterbalanced by weighted levers. A hydraulic cylinder, connected by a lever to the rocking-shaft, feeds the saw downwards. The rail to be cut is also cramped and uncramped hydraulically, and is held in such a position that the surface being cut at any moment is small. Water is lavishly supplied to the cut, but in spite of this showers of sparks are given off, as from a hot saw or dry emery wheel. The cut is as smooth and clean as if a slow-speed toothed saw had done the work, but the ends of the rail are blue, and warm to the hand. There is no appreciable burr formed on the work, but a flaky blue metallic lamination about the thickness of paper is sometimes made, which can be removed with the fingers. The edge of the saw does not wear, but in time cracks develop from the circumference inwards. These can be stopped by drilling a small hole through the saw at its inner end; but when there are more than one or two the saw is discarded. The saw will cut from 100 to 200 tons of rails a day, and, in fact, under favourable conditions, more than a rail a minute can be dealt with, including the time taken in getting the rails on and off the machine.

When the rail is of the exact length with well-finished ends it is ready to be drilled for the fish-bolts. Two holes have to be drilled through the web at each end exact as to position, and elongated so as to allow for expansion and contraction of the rail. Special machines built by Tangyes, of Birmingham, are used for this work (Fig. 9). There are four drill-spindles to each machine, adjustable all ways, to allow for bond-holes, etc. The drills feed inwards, and when

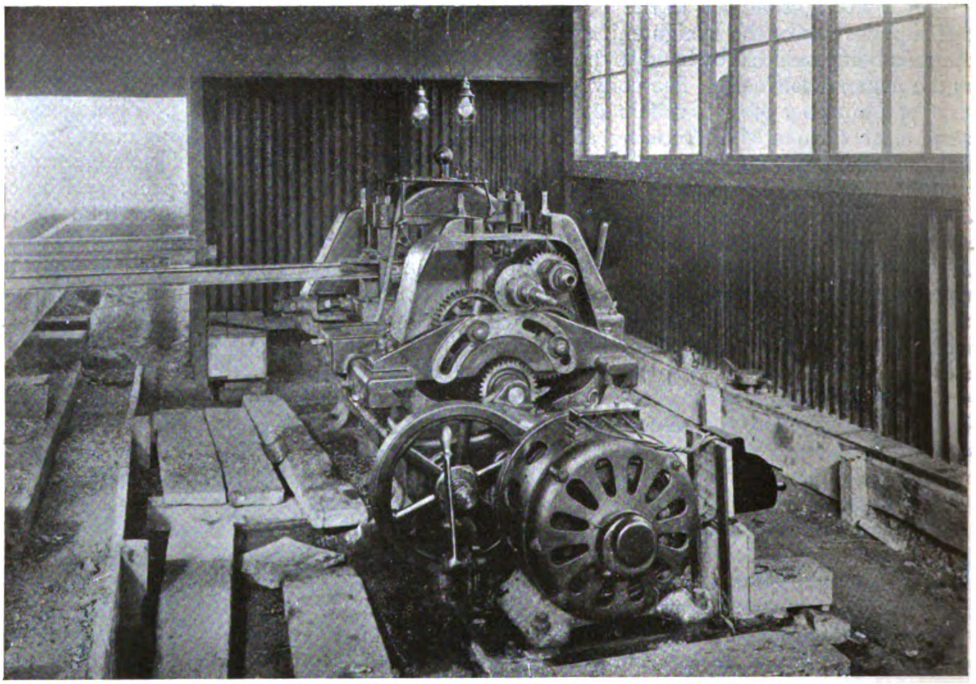


FIG. 9. RAIL DRILLING MACHINE.

through the rail the table on which the rail is clamped is worked forward on a slide by a screw until it reaches a stop, and thus controls the length of the oval.

When finished the rail is taken out and pushed into the opposite machine, which treats the other end in a similar manner. There are altogether six of these rail-drilling machines besides a punching machine which makes holes in rails where drilling is considered unnecessary.

Drilling is the last operation the rails have to undergo, and, in accordance with the lay out of the McKenna Works, they have by this time arrived at the exit of the shops. Behind the works is a siding, the rail-level of which is several feet below the yard-level, the yard terminating at the top of a concrete retaining-wall. The loading of the finished rails into trucks is thus a very simple matter, as they can be slid off the skids into the trucks without the intervention of a crane. Part of the yard equipment is a large automatic weighing-machine, registering up to 60 tons. It has a compound table, which will take either long or short trucks, and each part of the table may be used independently if required, or the whole table locked together. The weight is shown on an indicator, and also printed on a ticket by the machine.

Rails rolled by the McKenna process are not only indistinguishable from new rails, so far as weight and shape are concerned, but it is claimed that the extra working they receive makes them stronger and tougher than new rails. The company support their claim by the result of continual test of their product. McKenna rails usually show an ultimate tensile stress of from 40 to 45 tons per square inch, and an elongation of from 20 to 25 per cent. on 3in. These results compare well with the stipulations as to tensile strength contained in standard specifications for rails of high quality, and as a consequence the rails are largely adopted in the manufacture of points and crossings as well as for other work where special durability of material is required, besides being applied to the ordinary purposes of rails. The works of the company are capable of turning out something like 200 tons of rails per day, and since their inauguration have been exceptionally busy and prosperous.

THE STIRLING BOILER IN IRON AND STEEL WORKS PLANTS.

A. LASSELL.

THE Stirling water-tube boiler consists of two or more upper or steam drums and one or more mud drums, interconnected by nearly vertical banks of tubes. The three-drum boiler is used for the smaller sizes; Fig. 1 shows such a boiler adapted for the utilisation of waste heat. All the tubes are curved slightly to allow them to enter the drums radially. These curved tubes are one ot the great merits of the Stirling boiler. The bends offer no obstacle to the satisfactory internal and external cleaning of the tubes, and contribute to the low cost of maintenance by permitting of expansion and contraction without strain, thus obviating the cost of extensive repairs with attendant laying off, as are frequently met with in other designs of boiler. The steam spaces of all the upper drums are connected, while the water spaces of only the front and middle drums

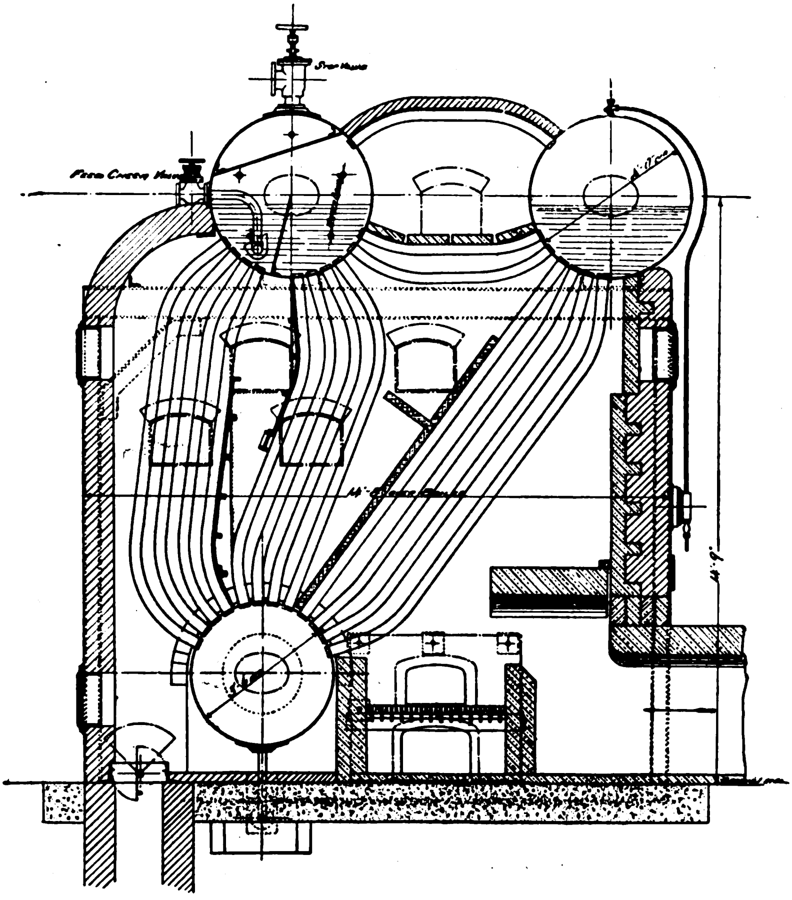


FIG. 1. SECTION OF THREE-DRUM STIRLING BOILER ARRANGED FOR WASTE-HEAT FIRING.

communicate. These drums and tubes form the boiler, hence a very high degree of simplicity has been attained in its construction.

The boiler is, by its design, a safety boiler. All parts subject to pressure are of wrought metal, and either spherical or cylindrical in form: thus any tendency to distortion under pressure is avoided.

On referring to the sectional view of the boiler, Fig. 1, it will be seen that a fire-brick arch is sprung over the grate immediately in front of the first section of the tubes. This arch absorbs heat from the fire, and becoming an incandescent radiating surface, ignites by radiation the new fuel as it is fed upon the fire. It also ensures all the hot gases from the fire passing into the front bank of tubes. It ensures an even distribution of the gases, and prevents their concentration at any one point.

By suitably disposed fire-brick partitions, or baffle walls, the gases from the furnace are led up or down each particular bank of tubes. In the long and circuitous path from the grate to the damper all the gases come in contact with the tubes, ensuring an exhaustive delivery of their heat to the water, and a high efficiency in the boiler. The feed water enters the rear steam drum, and as it descends to the mud drum is gradually heated by the hot gases on their final passage through the boiler before entering the chimney. In this back section the water is heated to a sufficient extent to render any lime salts that the water may contain insoluble. The precipitate is deposited in the form of mud or sludge in the mud drum, from whence it can be blown off as frequently as is found necessary. The feed water entering the boiler where the gases leave it is one cause of the high efficiency of the Stirling boiler. Should any of the precipitates collect in the rear bank of tubes, the heat of the gases is so reduced by the time they reach the last bank of tubes that the deposit is not baked hard, as it is in tubes directly in contact with furnace gases at their highest initial temperature. If the boiler is opened up at sufficiently frequent intervals, these precipitates can, therefore, be readily removed from the tubes

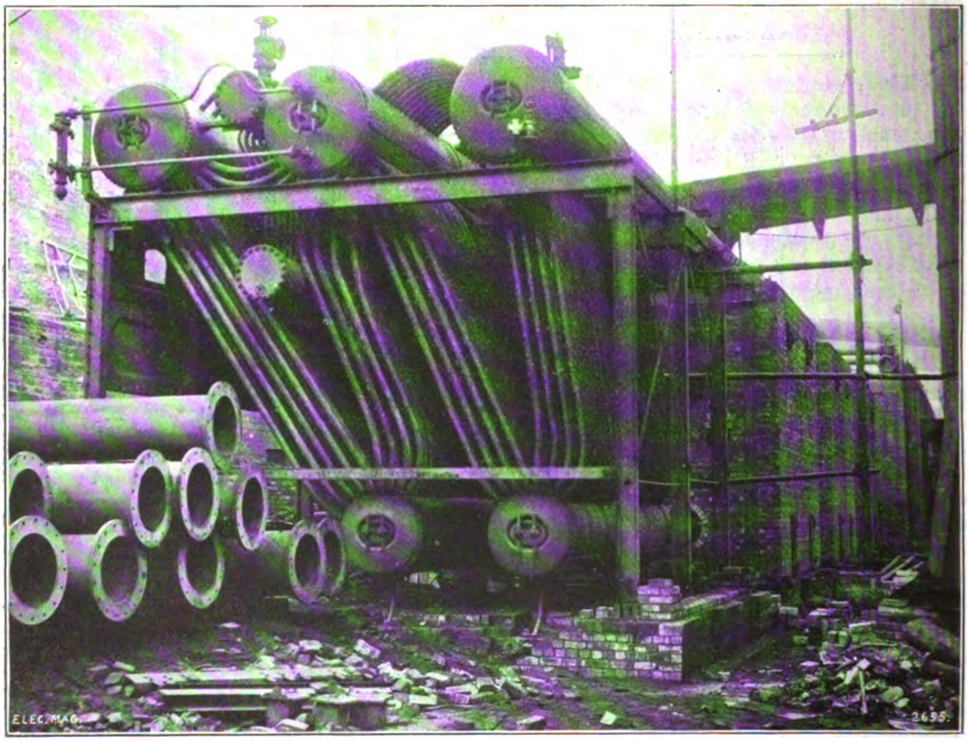


FIG. 2. BANK OF LARGE STIRLING BOILERS IN COURSE OF ERECTION: TO BE FIRED BY BLAST-FURNACE GAS.

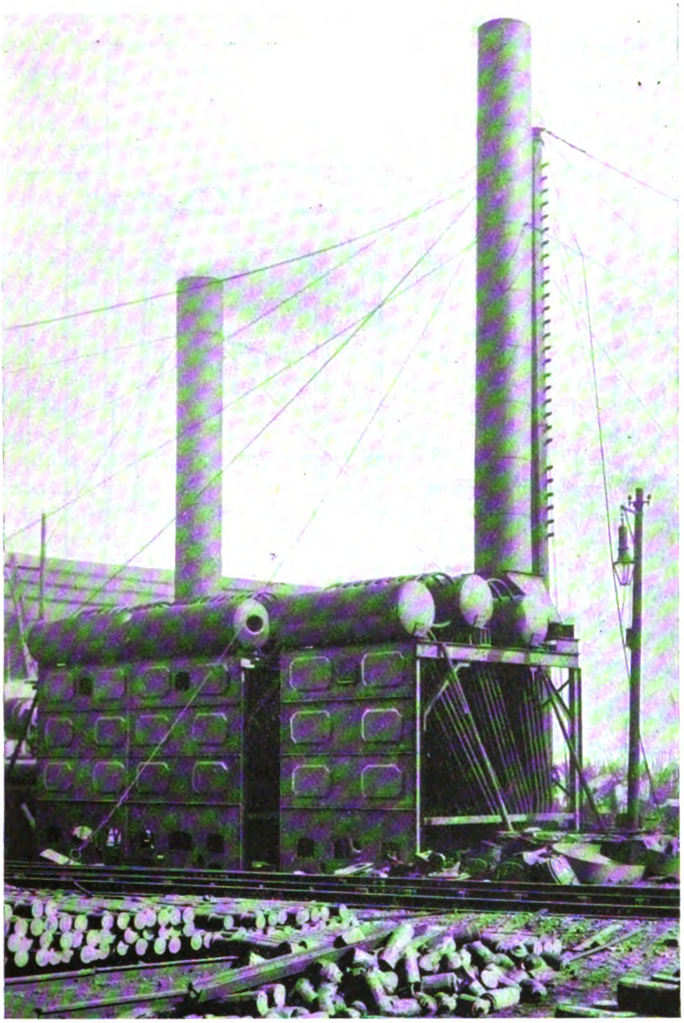


FIG 3. STIRLING BOILERS AS INSTALLED AT AN IMPORTANT BRITISH STEEL WORKS.

either by scraper or turbine cleaner. The water having been purified during its passage from the rear steam drum to the mud drum, the danger of scale formation in the parts of the boiler subjected to the greatest heat is removed, consequently the interior of these tubes remains clean, and heat is transmitted very rapidly to the water, thus not only preventing the tubes from becoming over-heated and burning out, but at the same time maintaining the efficiency of the boiler over a long period. Owing to the tubes being expanded directly into the drums every tube has an outlet to the steam drum equal to its full area, and this, combined with the vertical position of the tubes, ensures that there is no restriction of circulation, and consequently steam pocketing with its resulting evils is entirely avoided.

The removal of one manhole door from the end of each drum is all that is necessary to render accessible the interior of the drums and the ends of every tube. As the drums in the Stirling boiler are from 36in. to 48in. in diameter, a man may work inside with comparative ease and comfort. In cleaning the tubes of any scale that may be formed, the most satisfactory method is to use a turbine tube cleaner. This is worked by water pressure, and will readily and effectually remove the scale with no further labour on the part of the attendant beyond that necessary to guide the hose and cleaner attached.

As previously stated, little or no scale is formed in the front and second banks of tubes, so that only about one-third or one-quarter of the total number of tubes in the boiler require anything like frequent cleaning.

With regard to cleaning the exterior, cleaning doors are provided both in the sides and rear of the setting, so that the exterior surfaces of the tubes may be kept clean, and all accumulations of soot, dust, &c., blown off as rapidly as they form by using a steam jet, furnished with every boiler. The tubes being only slightly inclined from the vertical, there is little opportunity for soot and dust to collect on the outside surfaces.

The drums and tubes which form the boiler are supported independently of any

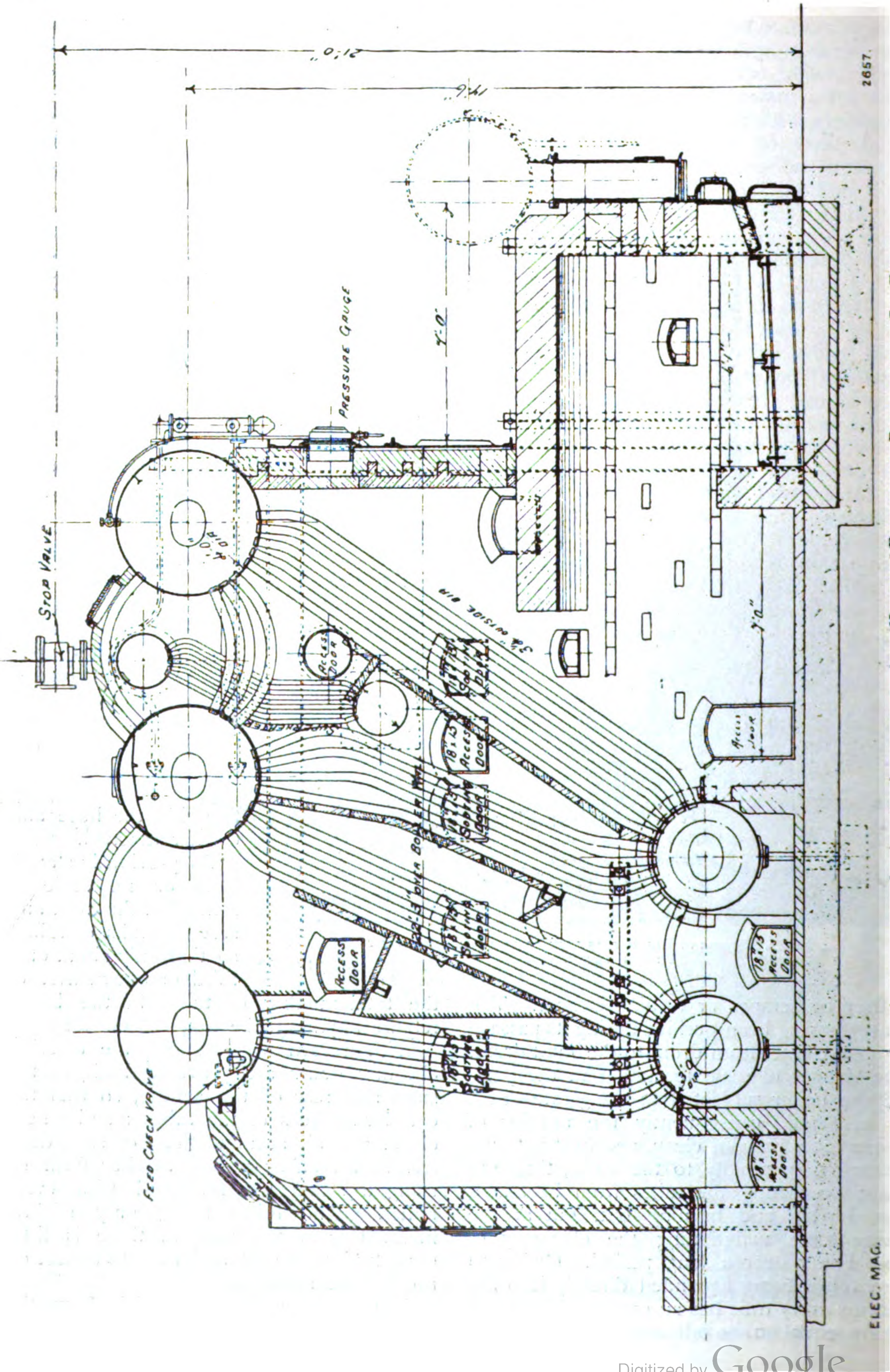


Fig. 4. Section of Five-drum Stirling Boiler as fitted with Harrison Furnace for Blast-furnace Gas Firing.

brickwork setting by steel frame-work, so that if necessary the brickwork may be removed and rebuilt without disturbing the boiler or its connections.

The mud drums are suspended by the tubes expanded into them, and as care is taken that the brickwork setting is built clear of the mud drums, these are left free to accommodate themselves to any movement from expansion and contraction, which, as before mentioned, is amply provided for by the curved tubes. The circulation of the water in the boiler is such as to maintain a uniform temperature in all parts, hence not only are strains and leaks due to unequal expansion and contraction avoided, but a longer life, greater durability, with lower " repair " accounts are ensured.

Should it be desirable to remove a tube from the Stirling boiler, it is only necessary to cut the tube from the tube plate, remove it through the doors provided for that purpose, introduce a new tube in the same way, insert it in the tube holes, and expand. In no event is it necessary to remove a good tube to get at a defective one.

As small units are generally required for utilizing the waste heat from furnaces, the three-drum boiler shown in the illustration Fig. 1 is the most adaptable; it has been specially designed for this purpose, and is in extensive use throughout this country. The large steam drums provided make the boiler eminently suitable for sudden withdrawals of steam for steam hammers, rolling mill engines, and the like. The illustration shows the boiler fitted with an auxiliary grate, so that it may be hand-fired if necessary from the side, the hot gases from the furnaces entering at the front. As will be gathered the boiler is particularly suitable for this service, affording as it does an ample and free passage for the hot flue gases, and presenting at the same time a large and efficient heating surface.

Many of the most important iron and steel works in the United Kingdom have installed Stirling boilers, and one of the most reliable proofs of the great success of the Stirling boiler for this work is the large number of repeat orders which the makers have received from such firms. Amongst the most recent important orders might be mentioned two installations of eight large boilers fired with blast furnace gas for two distinct firms in the North of England, and a group of four boilers, each of over 8000 sq. ft. of heating surface, gas fired, for steel works in Scotland. The long travel of the gases through the various banks of tubes, tends to make the boiler a peculiarly efficient one, and experience goes to show that it is particularly suitable for firing with blast furnace gas, waste heat from coke ovens, balling, piling, puddling, re-heating furnaces, soaking pits, &c.

The illustrations Figs. 4 and 5 show Stirling boilers as arranged for blast furnace gas-firing; the sectional drawing, Fig. 5, gives details of the Harrison furnace as used for this service. As will be seen from the drawing the furnace is of simple construc-

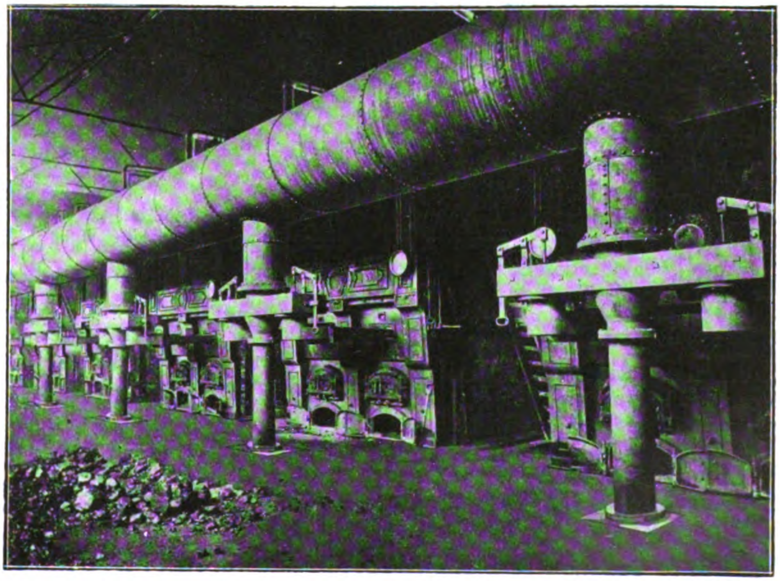


Fig. 5. Stirling Boilers arranged for Blast-furnace Gas Firing.

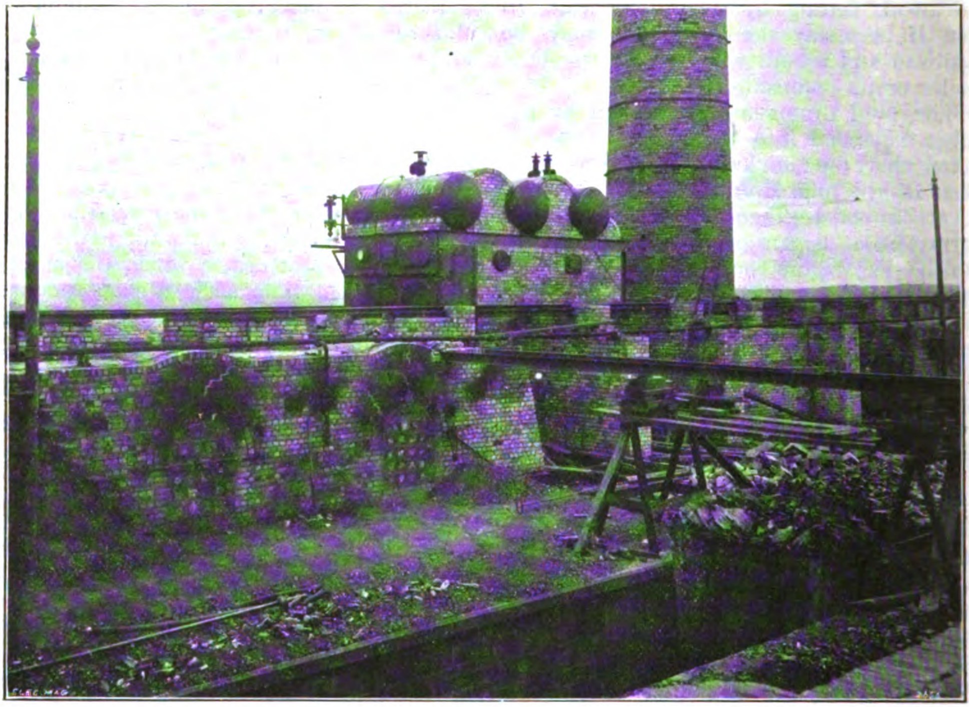


FIG. 6. INSTALLATION OF STIRLING BOILER; COKE-OVEN WASTE-HEAT FIRED.

tion; the gas supply is drawn from the large main into the cast-iron box on the furnace front, whilst the air is admitted through suitable doors over the gas inlet. The side walls of the furnace are hollow and the air which is fed into the furnace above the gas inlets is drawn through this hollow wall and is thus delivered to the furnace in a heated state; suitable baffles are fitted in the hollow furnace wall to ensure the air being properly heated before entering the furnace. The gas and air respectively enter through a number of ports, thus ensuring a complete mixture before combustion takes place. When the boiler is being gas-fired only, the hand-fired grate is covered with a layer of firebrick.

As illustrating the general steam-raising economy of the Stirling boiler, the following figures of tests made on a recent coke-oven plant installed at the works of one of the largest iron companies in the North of England and illustrated in Fig. 6 are interesting:

Duration of test	168 hours
Heating surface of boiler	4170 sq. ft.
Coke ovens, area per oven	134.5 sq. ft.
Form of furnace ...	47 coke ovens gas fired
Heating surface of superheater ...	295 sq. ft.
Average boiler pressure by gauge ...	157.4lb.
,, temp. of steam at above pressure	370deg. F.
,, temp. of superheated steam	476.2deg. F.
,, amount of superheat ...	106.2deg. F.
,, temp. of feed water entering boiler	61deg. F.
,, ,, of flue gases leaving boiler	500deg. F.
,, ,, of gases entering furnace	2228deg. F.
,, ,, of external air ...	50deg. F.
Total coal fired	1,389,696lb.
Coal as fired per hour	8,272lb.
Draught	.5in.
Total weight of feed water to boiler (actual)	2,136,700lb.
Equivalent water evaporated from and at 212deg. F.	2,734,976lb.
Factor of evaporation	1.28lb.
Water evaporated per hour	12,718.4lb.
Equivalent evaporation per hour from and at 212deg. F.	16,279.5lb.
Water evaporated under actual conditions per lb. of coal carbonised	1.537lb.
Equivalent evaporated from and at 212deg. F. per lb. of coal carbonised	1.968lb.

The following figures are the results of a test made on one of the three boilers illustrated in Fig. 3.

Duration of test	6 hours
Heating surface of boiler	3277 sq. ft.
Grate area	60 sq. ft.
Ratio of grate area to heating surface	1 to 54
Form of furnace	Underfeed
Average boiler pressure by gauge	130lb.
,, temp. of steam at above pressure	355.59deg. F.
,, ,, of feed water entering boiler	50deg. F.
,, ,, of flue gases leaving boiler	561deg. F.
,, ,, boiler house	50deg. F.
Fuel	Oak nuts
Calorific value of dry coal	13,464 B.Th.U.
,, ,, coal as fired...	12,930 ,,
Total coal as fired	8460lb.
,, dry coal consumed	8125lb.
Percentage of moisture in coal	3.97 per cent.
Total ash and clinker	602lb.
Percentage of ash and clinker	7.12 per cent.
Total combustible consumed	7523lb.
Coal as fired per hour	1410lb.
Coal as fired per hour per sq. ft. of grate surface	23.5lb.
Dry coal consumed per hour	1354.16lb.
Dry coal consumed per hour per sq. ft. of grate surface	22.56lb.
Draught	1 to 1.7in.
Total weight of feed water to boiler (actual)	73,600lb.
Equivalent water evaporated from and at 212deg. F.	89,350lb.
Factor of evaporation	1.214lb.
Water evaporated per hour (actual)	12,266lb.
Equivalent evaporation per hour from and at 212deg. F.	14,890.92lb.
Increase in evaporation per hour from and at 212deg. F. over guarantee	22 per cent.
Equivalent evaporation per hour from and at 212deg. F. per sq. ft. of heating surface	4.54lb.
Water evaporated under actual conditions per lb. of coal as fired	8.69lb.
Equivalent evaporation from and at 212deg. F. per lb. of coal as fired	10.54lb.
Water evaporated under actual conditions per lb. of dry coal	9.05lb.
Equivalent evaporation from and at 212deg. F. per lb. of dry coal	10.98lb.
CO_2 in flue gases	12 to 14 per cent.
Efficiency of boiler	78.77 per cent.

The Stirling boiler has been very widely adopted in iron and steel works in various parts of the Kingdom. In all there are some 130 boilers put down for this specific service, aggregating over 70,000h.p. in capacity and working with coal, coal-gas, blast-furnace gas, and waste-heat firing. In addition to these there is a very large number installed at collieries, many of which are fired with waste heat from coke-ovens.

* * *

CENTRIFUGAL PUMPS FOR IRON AND STEEL WORKS.

F. B. JACK.

About ten years ago most engineers held as a general opinion that the field of usefulness for centrifugal pumps was limited to the conditions of service in which the total head to be pumped against was low and the quantity of water discharged by the pump much in excess of that ordinarily dealt with by reciprocating pumps. Under these so-called favourable conditions a centrifugal pump was considered to be doing well if the efficiency reached 60 per cent.

The design of the centrifugal pumps at that period was no doubt responsible for the low efficiency generally obtained. In most pumps the impeller or disc was of the open type, so that the slip depended entirely on the clearance obtaining between the vanes of the revolving disc and the fixed casing. This arrangement not only caused considerable loss of efficiency in a new pump, but very soon decreased the efficiency owing to the rapid wear taking place on the vanes of the impeller. In such designs the pump had generally a low number of revolutions due to the large diameter of impeller, which was advantageous so far as it enabled the pump to be easily direct-connected to the slow-speed open-type engine then in vogue; but in pumps of moderate capacity there is no doubt the increased diameter of the disc also accounted for the low efficiency generally obtained.

The common use of centrifugal pumps of the type described went a long way to fix the impression in the minds of engineers that this type of pump was at the best inefficient and only capable of use within narrow limits.

Within the last five years, however, a very great change has taken place in the design of the best type of centrifugal pumps. Makers have abandoned the old methods of design, determined more or less by rule of thumb, and have adopted designs which are the results of most careful research and experiment. In place of the old-time open disc there is now the closed impeller, the angles and vanes of which have been determined with mathematical accuracy for any particular set of conditions. The pump casing is now designed so as to convert the velocity of the water issuing from the impeller into the required static pressure with the minimum loss from shock, &c.

In the old pump the bearings carrying the pump spindle were really long sleeves also forming the stuffing boxes for the pump. This combination was most effective in wasting power through undue friction, and as a consequence considerably shortening the life of the pump, especially in the case of all pumps dealing with water containing grit which could not be prevented from mixing with the lubricant.

The modern pump, in marked contrast to its predecessor, is provided with shaft bearings having continuous ring oiled lubrication; the bearing is entirely separated from the stuffing box, so that the lubrication may be unaffected by the nature of the liquid dealt with by the pump.

Looking at these two types of pump one may well ask what has brought about such a revolution in design, and the main reason is no doubt to be found in the introduction of the electric motor as a means of driving pumping machinery. Instead of being limited to the ordinary engine speeds high-speed electric motors can always be easily obtained for direct connection to centrifugal pumps, so that the pump designer

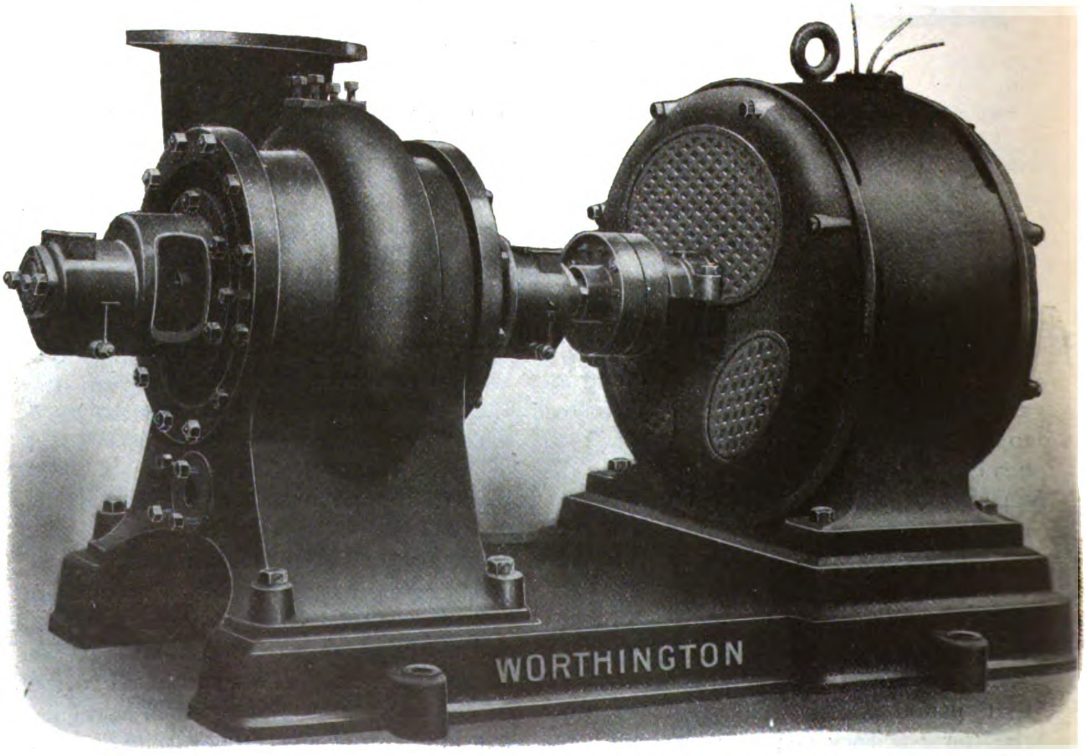


Fig 1. Worthington Standard Low lift Centrifugal Pump and Three-phase Motor as supplied to Steel Works.

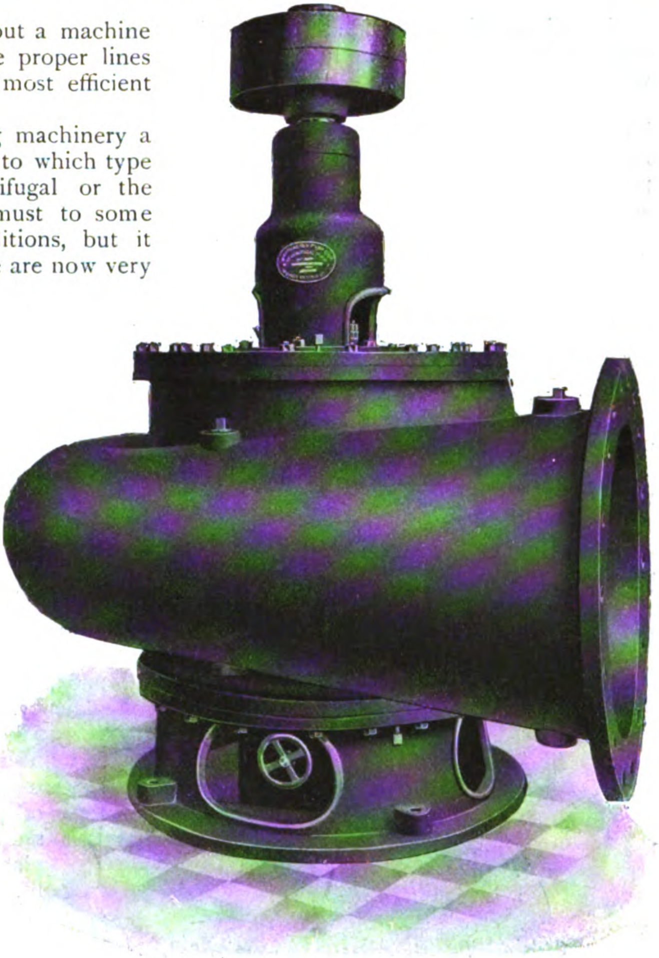


FIG. 2. WORTHINGTON VERTICAL CENTRIFUGAL PUMP AS SUPPLIED FOR STEEL WORKS POWER STATION IN MIDDLESBROUGH DISTRICT.

had little difficulty in getting out a machine which could be built on the proper lines with regard to obtaining the most efficient results.

In the choice of pumping machinery a difficulty sometimes arises as to which type is more suitable—the centrifugal or the reciprocating. This choice must to some extent depend on local conditions, but it may be safely stated that there are now very few services performed by reciprocating pumps which cannot be satisfactorily dealt with by centrifugals. In some instances the efficiency of the displacement pump is somewhat higher than the centrifugal, but taking into consideration the lower first cost maintenance, the reduced floor space required, and the convenience of handling, the centrifugal pump will successfully meet a general case. For example, if the conditions for which the pump is required be 500 gallons per minute against a head of 600ft., the power to be supplied by three-phase 50 period induction motor, the comparison will be as follows :—

	Cost with motor.	B.h.p. of motor.	Combined efficiency.	Floor space required.	Weight of pump and motor.
	£				Tons.
Reciprocating pump	725	123	68	16′ 6″ × 9′ 3″	13·5
Centrifugal pump ...	430	127	67	13′ 0″ × 4′ 0″	4·5

In addition to the advantages as shown by the above comparison, it must also be borne in mind that the risk of accident is much less with the centrifugal pump than can possibly be the case with the reciprocating machine, seeing that any sudden closing of valves or stoppage in the delivery pipe would not affect the pump except in so far as to reduce the load on the motor.

In cases where the quantity of water to be handled is very small as compared with the head, it must be admitted that the advantage is with the displacement pump. To deliver, say, 50 gallons per minute against a total head of 500ft. would be only possible with a centrifugal pump running at an abnormally high speed. Such a pump, if used, would give considerably lower efficiency than would be obtained with a well-designed displacement pump, but this is an exceptional case and does not affect the general proposition.

At the present time, the problem of high lift centrifugal pump work has been so far mastered that there is practically no limit to the head against which these pumps will work satisfactorily, provided always that there is the correct minimum quantity of water to be dealt with.

Centrifugal pumps may be roughly divided into three classes: low lift, medium lift, and high lift. To the first class belong all pumps usually employed for delivering against heads not exceeding 70ft. For such services as circulating water through condensers, general water supply for steel works, &c., this type of pump is most suitable. Fig. 1 shows a standard Worthington low-lift pump arranged with an electric motor similar to a large number of pumps supplied to steel works in the North of England.

In special cases where a variable and excessive suction lift has to be met with, this type of low-lift pump has been arranged to work in a vertical position with most satisfactory results. The general appearance of a pump so arranged is shown in Fig. 2, several pumps of this type being recently installed by the Worthington Company in the Middlesbro' district.

Fig. 3 illustrates a 22in. Worthington low-lift pump recently built for a large electric power station on the North-east coast. This pump on testing gave a maximum efficiency of about 85 per cent. as shown by the curves Fig. 6 on page 344, and in this respect it is a very marked contrast to the results formerly obtained with other designs. An examination of the curves will show that the high degree of efficiency is obtained over a very wide range of capacity, and the popular idea that a centrifugal pump will only give good efficiency at a fixed capacity is clearly disproved by the results shown on the curves.

Assuming that the static head is constant and it is required to reduce the capacity by throttling the discharge while the pump continues to run at a constant speed, the reduction in efficiency for 25 per cent. reduction in capacity will only be about 5 per cent., and for a 50 per cent. capacity, 20 per cent. below normal efficiency.

It should also be carefully noted that if the static head is variable, and should by any means in an extreme case be reduced to zero, then the power required does not exceed in this case 15 per cent. more than the normal b.h.p. necessary at the highest point of efficiency. This is a most important point in view of the numerous cases of complaints made by users of centrifugal pumps that the motors are burnt out owing to an abnormal increase of power absorbed by the pump when a reduction in the head has taken place. In the Worthington low-lift centrifugal pump, however, it is not necessary to provide a motor of other than the normal overload rating.

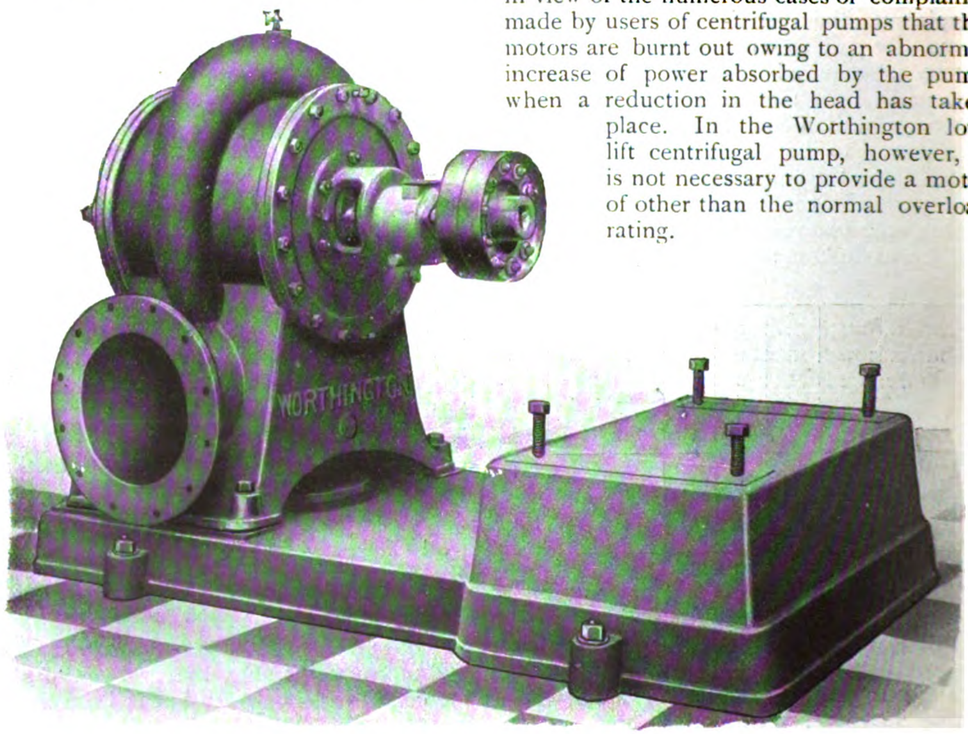


Fig. 3. Worthington 22in. Low-lift Centrifugal Pump with Base-Plate for Electric Motor.

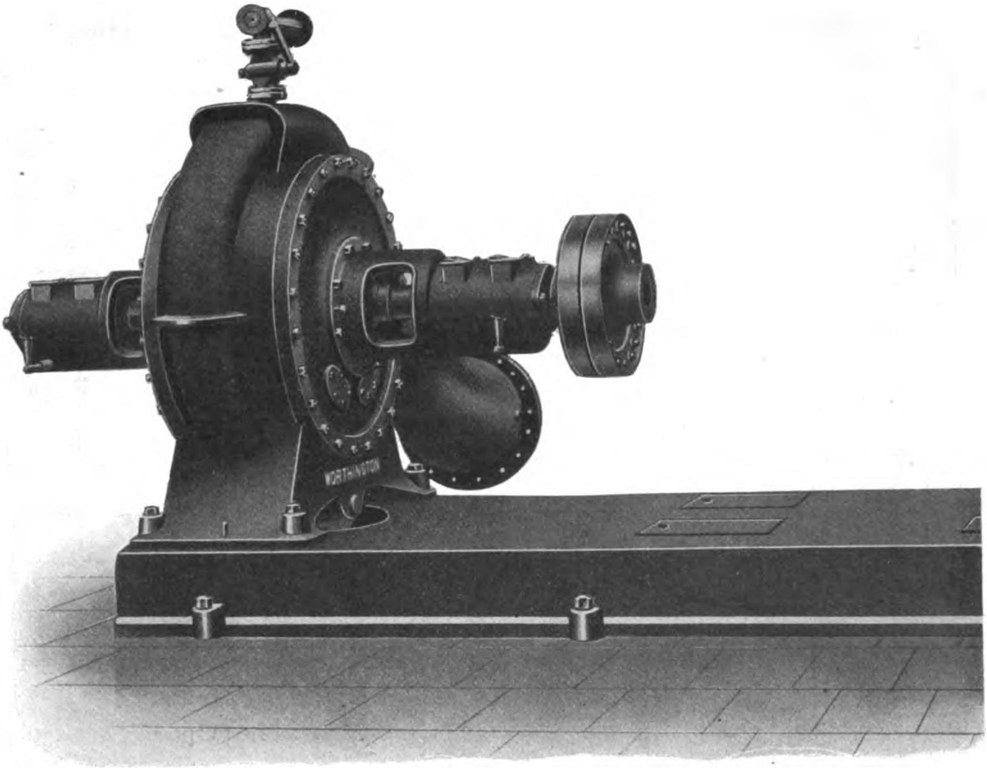


Fig. 4. Worthington Medium-lift Centrifugal Pump. Capacity 3500 galls.; Head 105ft.

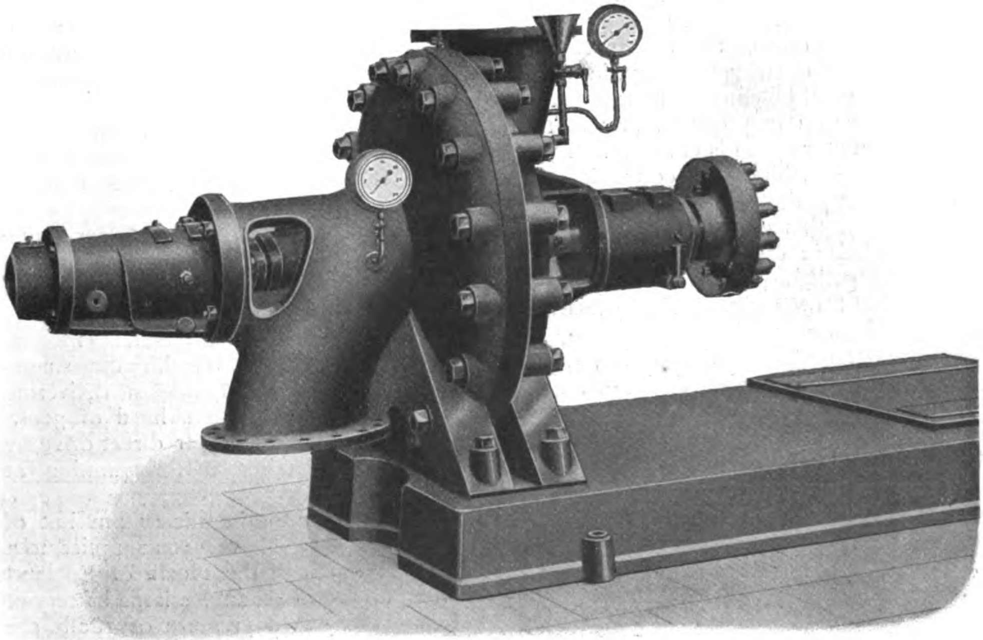


Fig. 5. Worthington High-lift Centrifugal Pump (New Design). Capacity 2500 galls.; Head 300ft. Bed-Plate Arranged for Three-phase Motor.

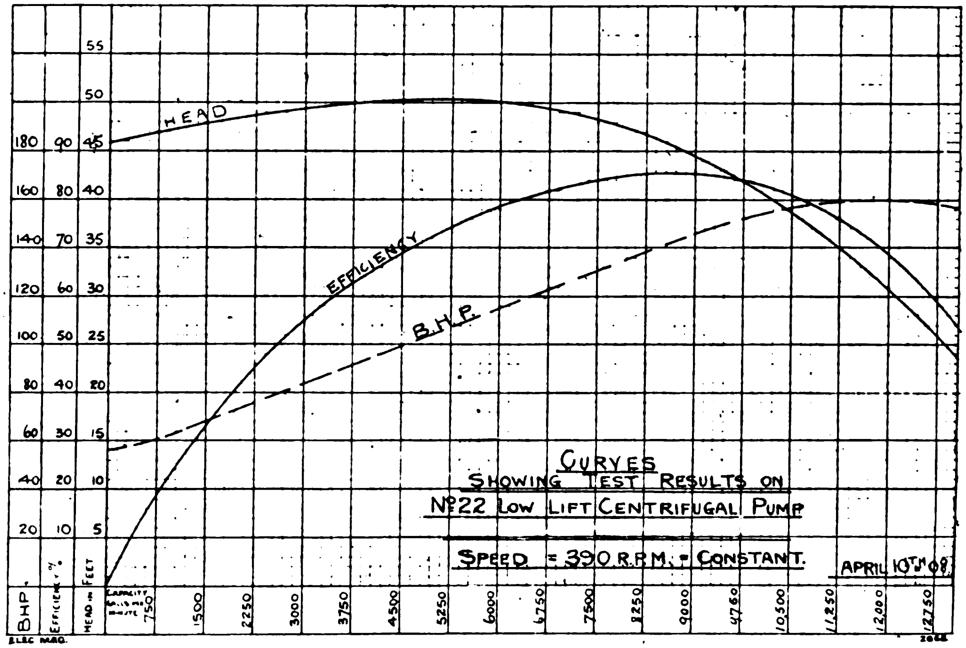


FIG. 6.

In all blast-furnace works a supply of water for cooling the tuyères is of the greatest importance, and is a service which requires that the supply from the pumps shall be without fluctuation in pressure. This is perhaps one of the best features of a well-designed centrifugal pump, in which the discharge will be continuous without the slightest variation in pressure, provided, of course, the motor speed is constant. Fig. 4 represents a Worthington medium lift type of pump as supplied to one of the largest iron works in this country. These pumps were installed in duplicate, and each delivers 3500 gallons per minute against an effective head of 105ft. The design of the Worthington medium lift pump is somewhat different from the low lift, having a special diffusion chamber designed to give the increased head without the necessity of using guide vanes.

When the head against which a centrifugal pump requires to work exceeds 150ft. it is usually necessary to employ a type of different design from either of the foregoing. In most normal cases a multi-stage pump is used, these pumps being supplied in single units made up sometimes of as many as eight stages. In these pumps it is usual that each impeller delivers through a set of multiple diffusion vanes for the purpose of converting the velocity into pressure, and so long as the water is clean this design is satisfactory. Certain difficulties arise, however, when these pumps have to handle gritty water, and to effectively deal with this condition the Worthington Company have successfully developed a new design of high-lift centrifugal pump, in which there are no guide vanes. This new pump is considerably simpler than other designs, and in many respects more efficient.

Although most widely used for mine drainage the high-lift centrifugal pump has a large field of usefulness in steel works, and has been successfully adopted where a large pressure supply is necessary. The illustration Fig. 5 shows a Worthington single-stage turbine pump capable of delivering 2500 gallons against a total head of 300ft. This pump was arranged for direct drive by three-phase induction motor running at 1150 revolutions.

Pumps similar to the illustration but of the multi-stage type have been supplied to a large steel works in the North of England for the purpose of feeding a large battery of boilers working at a pressure of 180lb. per square inch. These pumps are also electrically driven by three-phase motors.

MODERN ELECTRIC CRANE PRACTICE.

F. W. HOLLICK.

ABOUT three years ago the firm of Messrs. Babcock & Wilcox, Ltd., who have manufactured for many years with such success their patent water-tube boilers, took over the business and staff of the old-established firm of crane manufacturers, Messrs. Wimshurst, Hollick & Co., Ltd., and added this as a new department to their already extensive business. The wisdom of this step by Messrs. Babcock & Wilcox

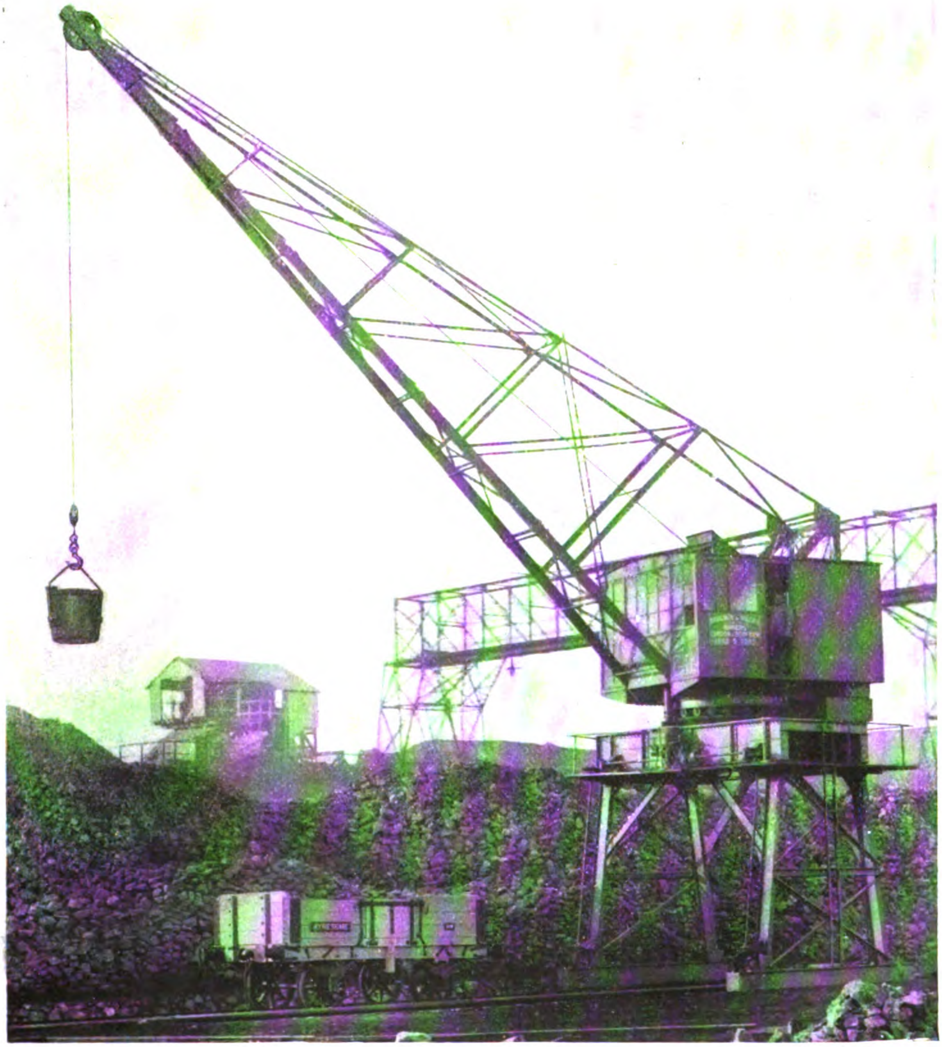


FIG. 1. FIVE-TON JIB CRANE HANDLING IRON ORE IN CLEVELAND DISTRICT. (BABCOCK AND WILCOX, LTD.)

into a highly specialised field of engineering manufacture is already very apparent; this branch of the business has during the past two years increased very rapidly, and many large contracts have been very successfully executed for the British Admiralty, and many of the leading engineers, harbour boards, lighting stations, &c.

In order to obtain the best possible results, extensive new shops have been erected at Renfrew, and equipped with all the most modern appliances for producing the highest quality of work at the lowest possible cost. To meet the demand for high-speed electric overhead travelling cranes, a complete set of standard sizes have been worked out, capable of lifting from one to sixty tons, and ranging in span from 25ft. to 110ft. A large staff of competent draughtsmen have been engaged on the work, and every care has been taken to produce the most efficient and economical designs. The cranes are fitted with every convenience for working with safety, speed, and ease.

The cranes illustrated in Fig. 2 are now being constructed for a large ironworks in the North of England for service over new pig beds and stocking yard. They are to be of 110ft. span, and constructed to lift 5 tons at a speed of 30ft. per minute, or $2\frac{1}{2}$ tons at 60ft. per minute, and to travel longitudinally at 400ft. per minute, whilst the speed of traverse is 300ft. per minute. The electrical equipment is being supplied by Messrs. Warren, Beattie & Co., and is to be suitable for working on a 220-volt circuit continuous current. The motors are totally enclosed and capable of develop-

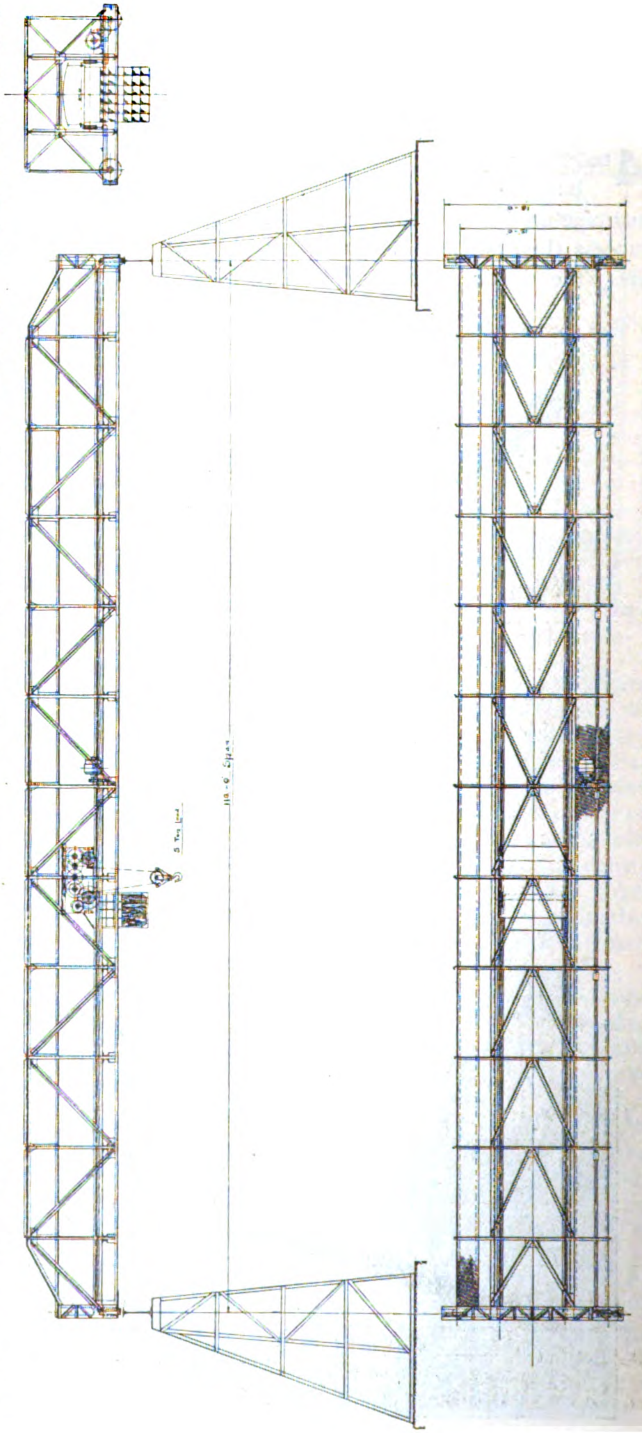


FIG. 2. FIVE-TON ELECTRIC PIG BED CRANE BY BABCOCK & WILCOX, LTD.

ing the following horse powers:—hoisting, 15h.p.; long travel, 18h.p.; traverse, 7½h.p. The girders are of the lattice-braced type, as will be seen from the illustration, Fig. 1. The carriages have a very long wheel base, thereby ensuring easy and safe running at high speeds, and are fitted with heavy cast-steel travelling wheels.

The longitudinal travelling motor is fitted at the centre of the girders and drives the travelling bridge through cut spur gearing. The crab frames are of mild steel fitted with self-aligning bearings for carrying the shafts for the hoisting and transverse travelling motions, thereby ensuring perfect alignment and free running. The general design of the crabs is very neat, the head-room required very small, and the wheel base so arranged as to give the maximum cross travel, thus allowing the load to be handled as near as possible to the gantries.

Another very important matter which has been very thoroughly dealt with is the question of braking. A very powerful automatic brake is fitted on an extension of the lifting motor shaft capable of holding the full load and so arranged as to come into immediate operation should the current fail from any cause. This brake is also fitted with gear so that it can be operated by hand from the driver's cage in case of need. In addition to this automatic electric brake there is provided another, which is also capable of dealing easily with the full load and which is mechanically operated from the driver's cage. A powerful magnetic brake is also fitted on the longitudinal travelling gear, so that the crane can be stopped in a short distance when travelling at a high rate of speed.

A neat mechanical screw arrangement is driven from the barrel shaft, which auto-

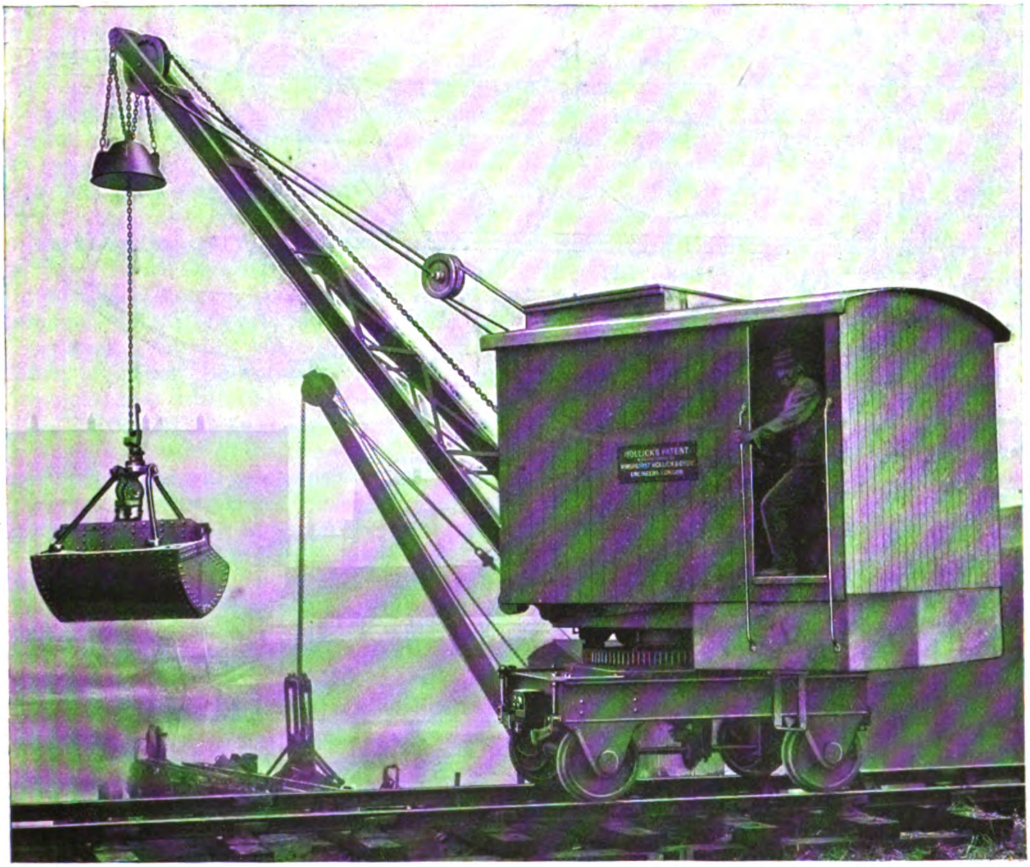
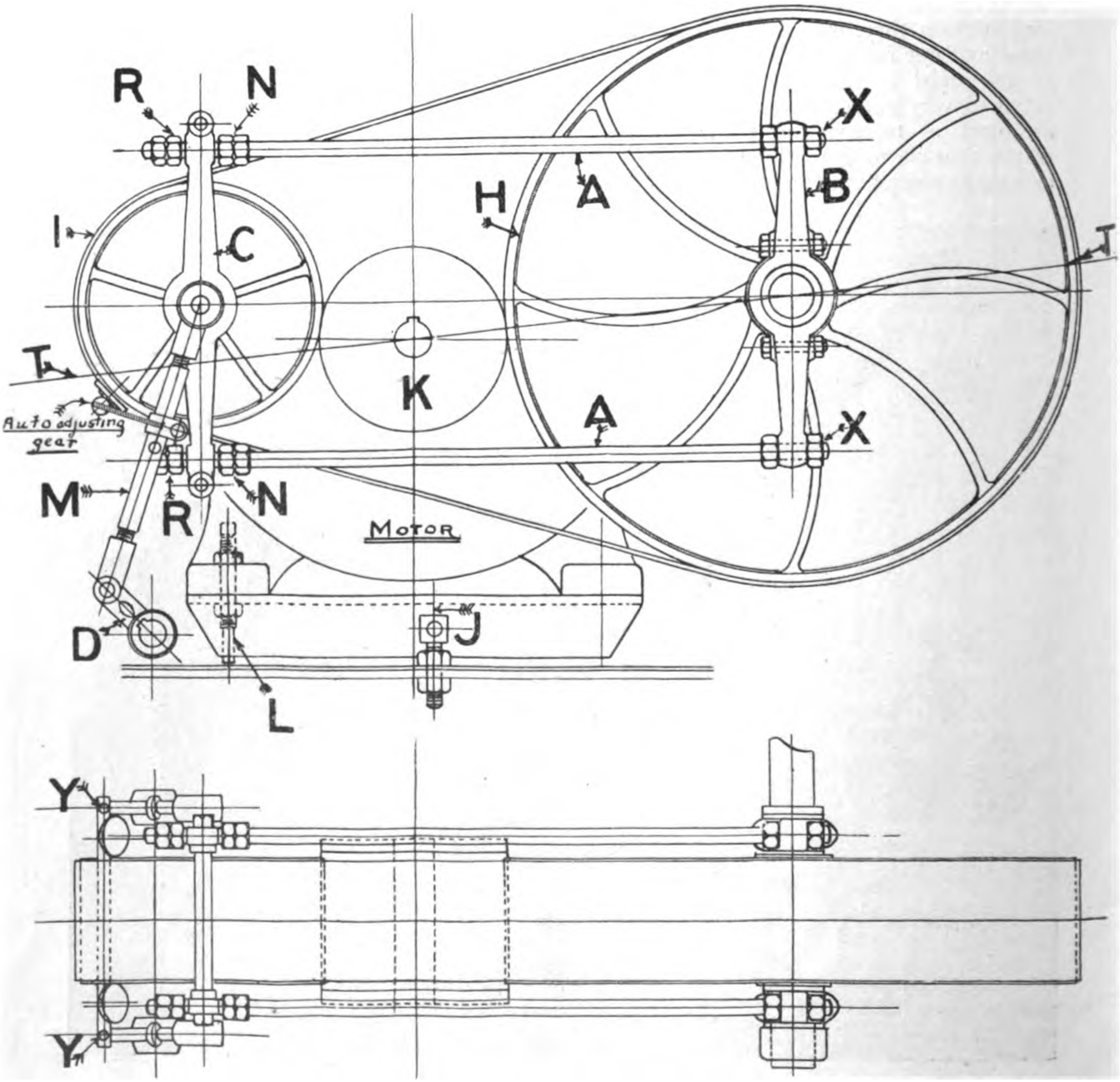


FIG. 3. THREE-TON COAL-DISCHARGING CRANE BY BABCOCK & WILCOX, LTD., FITTED WITH HOLLICK'S PATENT BALANCED FRICTION GEAR.

matically cuts off the current and applies the brakes at a given height of lift, thus ensuring that no damage can be done by carelessness on the part of the attendants by over-winding.

Another type of crane which has recently been supplied to important ironworks in the Cleveland district is shown in the illustration, Fig. 1, page 345. This is a jib crane for handling iron ore, and is fitted with three motors for operating the hoisting, slewing, and travelling motions respectively. The crane is capable of lifting five tons at a speed of 75ft. per minute, three tons at 150ft. per minute; slewing at 400ft. per minute; and travelling 50ft. per minute. The radius of the jib is 45ft. The crane is mounted on a high under-carriage having a span of 15ft. to allow of railway wagons being shunted underneath. The crane is of the free barrel type, being operated by patent "Cryptic" gear, enabling the most rapid handling of iron ore.

The current is taken to the crane by means of a bare main protected by a wooden culvert, from which the current is collected by means of slipper contacts.



Figs. 4 and 5. Hollick's Patent Balanced Friction Gear.

But perhaps the most interesting type of crane manufactured by Babcock & Wilcox is their patent single-motor jib crane, which is standardised in all sizes up to ten tons, and has been specially designed to meet the demand for a strong, simple, reliable and handy crane. This type has been specially designed for use on wharves for loading and discharging vessels, and for contractors' work generally, and it has been extensively used with great success for these purposes.

The illustration Fig. 3 shows a crane supplied to the Marylebone Electric Lighting Station, which is fitted with a patent clam-shell grab for digging coal from barges, and discharging it into hoppers. The most interesting feature of this crane is the gear which transmits the power from the motor to the first motion shaft, and which is known as the Hollick patent balanced friction gear. This gear has been in successful operation for some years on cranes, but as it may not very generally be known it will be of interest to give a somewhat detailed description of it. The principle of the arrangement will be seen by reference to the lettered diagrams Figs. 4 and 5. The motor is not bolted down in the usual manner, but is carried on a shaft, "J," so that it is free to oscillate, and the shaft being out of the centre of gravity of the motor, the latter always has a tendency to fall away from large pulley "T" as shown; the motor frame is fitted with a dumping screw "L," so that the amount of its travel oscillation can be regulated. On the shaft of the motor is fitted a paper pulley marked "K," so arranged that when the small back pulley "I" carried in the swinging frame "C" is lowered by means of the cranks "D," which are operated at will by the driver, the paper pulley and the two larger pulleys come into contact, causing the large pulley to rotate. In the first instance the motor is started, when the paper pulley is disengaged, and allowed to run. Round the two larger pulleys is an endless belt, which takes the necessary pressure, thus relieving the bearings; there is consequently no loss of power due to friction. The bolts "AA" do not take any strain when the gear is in operation, but merely serve to stretch the belt, and to keep the back pulley in its proper position when out of gear.

It will be observed that the belt has to run on a broad flat-faced pulley, and some trouble was originally found in making this belt run perfectly central. In order to overcome the difficulty an ingenious and simple device was got out as follows. Placed close to the edges of the belt are two fibre rollers connected by lever "Y" to the rods "M." These rods are fitted with right and left hand screws so that when they are revolved the legs shorten or lengthen, raising or lowering edge of pulley as required, which automatically adjusts position of belt.

The objects of this interesting gear are:—

1. To form a starting and stopping device, which puts the whole crane under command by means of one lever only, without interfering with the driving motor or having any complicated electrical arrangements to be attended to.

2. To give an easy start to the crane and one which does not cause shocks; if the load fouls anything while in motion the gear simply slips and no serious damage is caused.

3. To form a highly efficient transmission gear and one which enables a constant-speed motor running at a high speed to be used, without the least fear of bearing troubles.

The rest of the crane may be briefly described as follows. The pulley "T" is keyed on to the first motion shaft of the crane, and on this shaft are also fitted the bevel friction cones of the usual well-known type for slewing, a set of clutch gear for operating the derricking and travelling motions, and the hoisting pinion.

The barrel shaft is fitted with a large chain drum to suit the hoisting chain, and also with the main spur wheel and brake wheel. The slewing is operated through spur and bevel gear driving on to a heavy cast-steel spur rack. The derricking is derived from the first motion shaft by means of worm gear driving a barrel: and the travelling motion is obtained by means of a shaft through the centre of the column driving both axles by means of bevel gear.

The speed of hoisting is 100ft. per minute, slewing 300ft. per minute, and travelling 150ft. per minute.

The bedplates, cheeks, carriage, &c., are all of mild steel, very strongly constructed, and suitable for the heaviest classes of work. A neat arrangement of rubbing contacts for conducting the current to the motor is fitted, and very special attention has been paid to thorough lubrication. The crane generally is a very complete machine, and the design is thoroughly carried out in every detail.

THE ELECTRIC DRIVING OF AUXILIARY MACHINES IN IRON AND STEEL WORKS.

H. H. B. DEANE.

THE driving of the auxiliary machinery of iron and steel works and allied trades has presented some very interesting problems in connection with the method of coupling up the electric motor to the machine in question. In the case of new machines, however, this is greatly simplified owing to the fact that all the good makers of heavy tools have now adapted their patterns with a view to attaining the highest economy from the motor drive, and also of utilizing the advantage of being able to place the motor on the top of the machine, thereby securing a very compact tool, keeping all the driving mechanism out of the way of the machine hand, and minimising the floor space required.

To obtain these points when converting existing machines from either steam or belt drive, is at times a very awkward operation. In the case of the straightening machine illustrated in Fig. 1, this was achieved by supporting the motor with the first motion shaft carrying a heavy flywheel on cast-iron frames fitted on to the machine bedplate.

Owing to the adoption of a heavy flywheel it was found that a 10b.h.p. motor was well able to do the work, whereas in the case of the machine shown in Fig. 2 a 15b.h.p. motor was fitted and is found to be very heavily loaded, although the duty of the two machines is similar. A comparison of the two machines shows how the expenditure of a little thought, and the allowance of a slightly higher first cost were rewarded by the greatly increased general handiness of the completed outfit, and goes far to illustrate the folly of cutting down capital expenditure in such matters to the lowest possible amount, at the expense of the ultimate economical utility.

This latter policy is again illustrated by a comparison of the driving arrangements of the machines shown in Figs. 3 and 4 where the compactness and handiness of the equipment

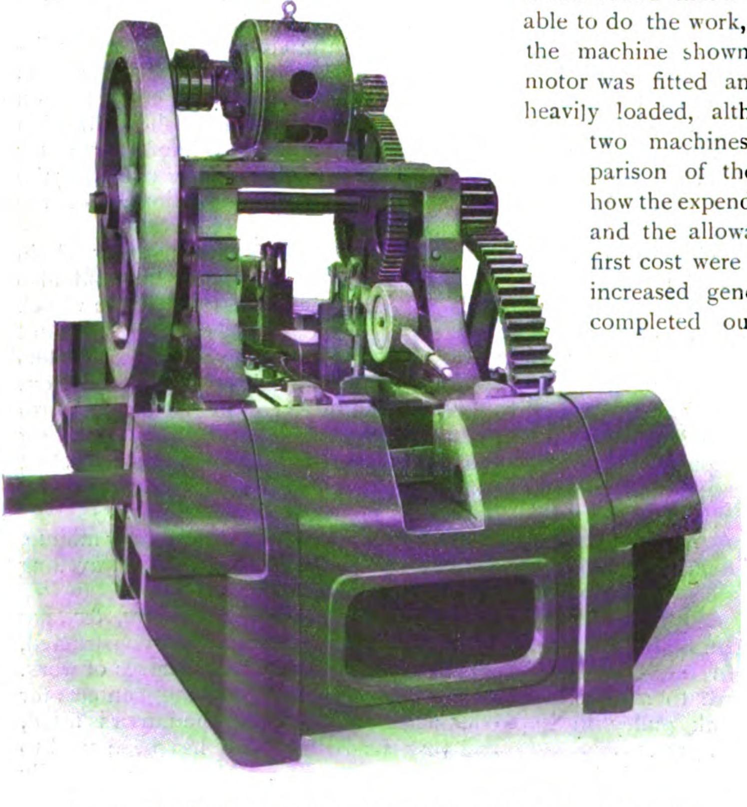


FIG. 1. BAR GIRDER OR CHANNEL STRAIGHTENING MACHINE, WITH GENERAL ELECTRIC COMPANY "WITTON" THREE-PHASE MOTOR.

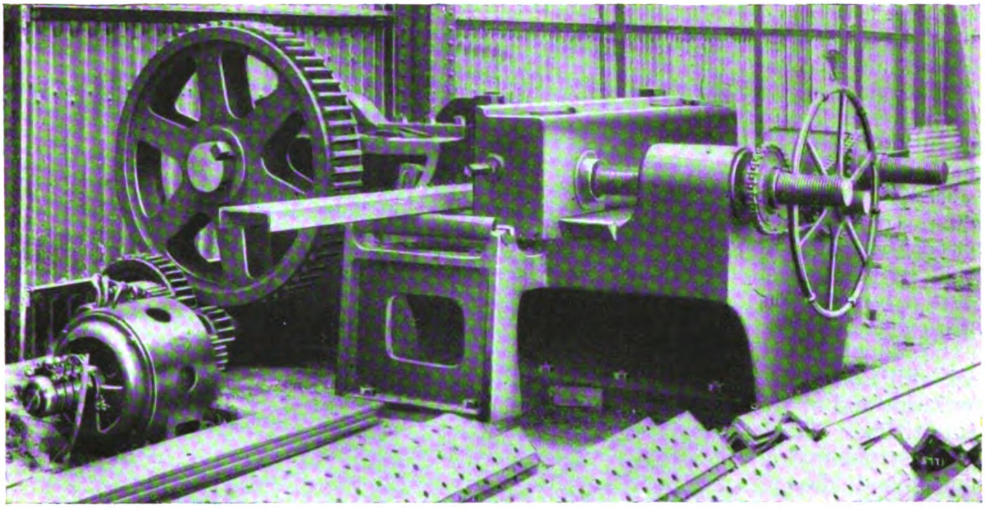


Fig. 2. Bar Girder or Channel Straightening Machine, with General Electric Company "Witton" Three-phase Motor.

in Fig. 3 is self-evident against that illustrated by Fig. 4. The latter could obviously have been much improved by supporting the motor on either a cast-iron or built-up steel frame bolted on to the shoulder of the main frame, the belt drive being still retained if deemed necessary owing to the character of the load.

Belt driving in these classes of tools is generally to be preferred to direct gearing owing to the fact that the vibrations of the machine and pulsation of the load are to a great extent cushioned out by its use. The load pulsations can however be better dealt with by the application of a sufficiently heavy flywheel. The equalising effect of flywheel storage was, however, a principle not sufficiently utilised by electricians in their early

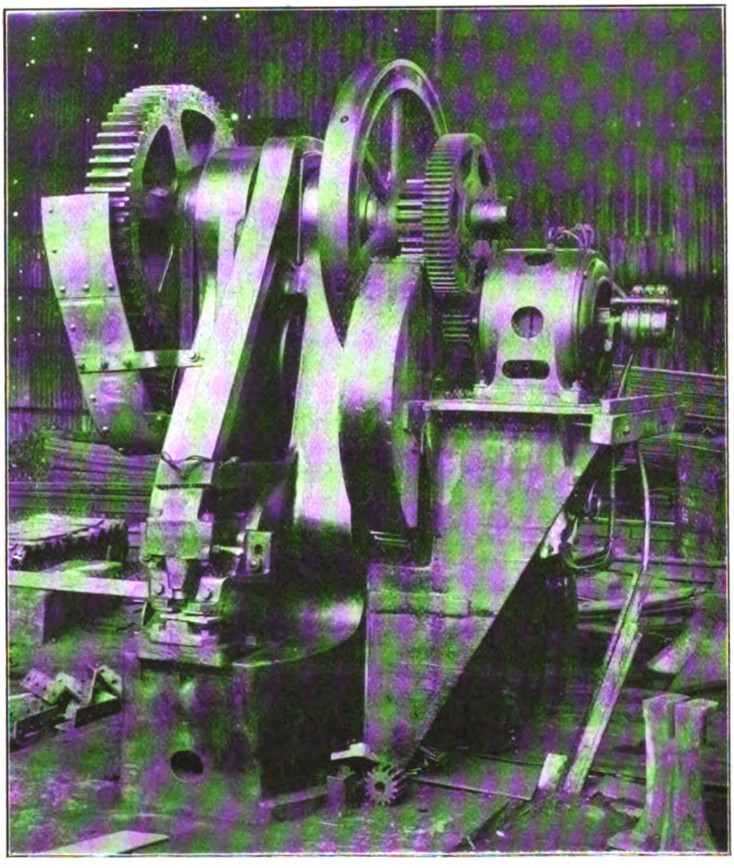


Fig. 3. Double Punching Machine, with "Witton" Three-phase Motor.

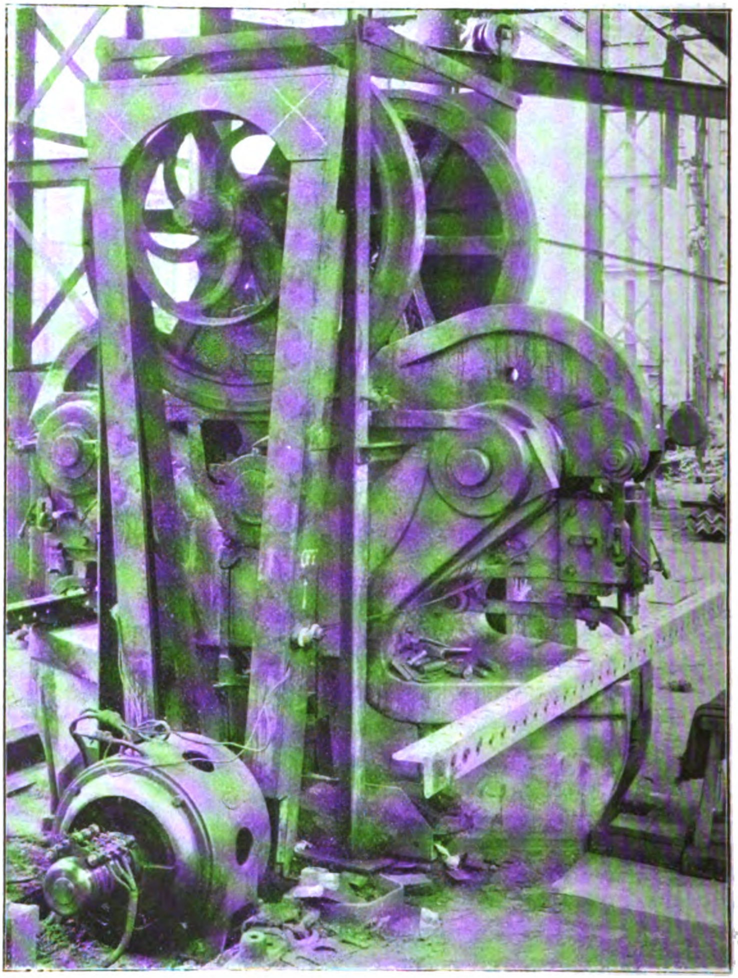


FIG. 4. DOUBLE PUNCHING MACHINE, BELTED TO "WITTON" THREE-PHASE MOTOR.

work, but it is being more extensively adopted now that its efficiency in dealing with heavy or intermittent load shocks has been fully realised. To illustrate this point a case that occurred recently might be mentioned where a heavy cold-shearing machine was to be supplied to deal with iron slabs 18in. wide and up to 2½in. thick. The makers stated that a shunt-wound direct-current motor with a 65b.h.p. continuous rating would be required; after discussion it was decided to considerably increase the flywheel effect and put in a 25b.h.p. motor very heavily compounded so as to attain the speed drop with full load necessary to enable the flywheels to give out their stored energy and equalise the demand upon the motor. From the running performance of the equipment it is evident that the right line was adopted, as the instruments show that the motor on the heaviest cuts is required to give out 30b.h.p., and of course this is an intermittent overload which can be easily handled by the standard 25h.p. motor installed.

* * *

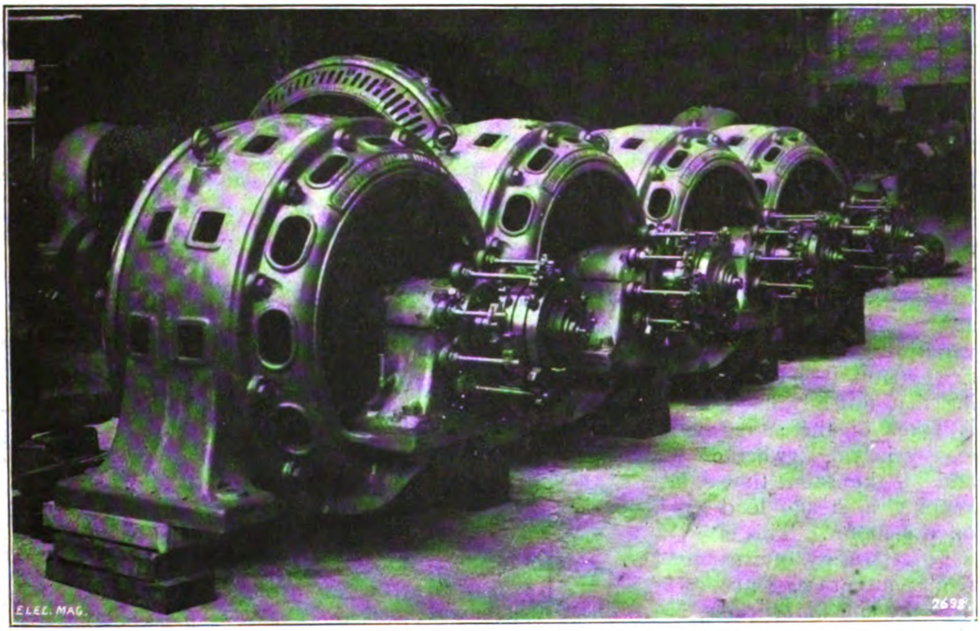
Franco-British Exhibition.

It is intended to publish in the next issue of THE ELECTRICAL MAGAZINE *a full and original account of the Electrical Interests at the Franco-British Exhibition, together with general descriptions of those features which appeal forcibly to the industrial community, and which require to be treated in the comprehensive manner compatible with the great International importance of the subject.*

NOTEWORTHY INSTALLATIONS, PLANT, AND APPARATUS.

Induction Motors for Steel Works' Service.

As most of our readers are no doubt aware, the great bulk of the electric driving in rolling mills has been carried out on the Continent; to a great extent the conditions there are more favourable to the exploitation of electricity for this purpose, owing to the high cost of coal. There are, however, undoubted signs that the British manufacturers are also realising the advantages of electricity in this connection, as is evident from the several important contracts recently placed for extensive electrical equipments by well-known firms of steel makers. In this connection it is interesting to note that one of the leading Scottish electrical firms has been making a special study of rolling mill driving, for some considerable time past; the British Electric Plant Company, of Alloa, Scotland, whose works are of the most up-to-date type, have made great strides in the application of three-phase plant to this special service. This firm has recently completed the entire electrical equipment of a heavy tube mill, the motors throughout being of the three-phase type. This is believed to be one of the first applications of electricity to this class of work, and the results have been such as to ensure the adoption of further work of this kind in the future. The British Electric Plant Company have also, for some considerable time past, supplied both three-phase and direct-current motors for driving the live rolls on



Three-phase Steel Works Motors by British Electric Plant Company, Ltd.

ordinary bar and rail mills. They have also several large motors in use driving sheet rolling mills with every success. Their motors have also been supplied for fixing to the top of the mill housings for the raising and lowering of the rolls. Another important branch of the electrical equipment is in connection with the handling of materials, and the Company has fitted a large number of cranes in steel works with both three-phase and direct-current motors, and have also their motors driving furnace-charging machines. It will be seen, therefore, that this firm has practically covered the whole ground for the application of electricity in connection with the standard steel works.

It is of interest to learn of one particular point in rolling mill driving, to which the British Electric Plant Company attach very great importance, and that is the correct ratio between the power of the driving motor and the size of the flywheel on the mill. As is generally known, the load on a rolling mill is exceedingly variable, and in the ordinary way this would result in the motor requiring a very large variation in supply, producing a most erratic load on the electrical generating plant, and requiring an exceptionally large motor to meet the demands at heaviest loads. The British Electric Plant Company, by the use of an automatic device, has so arranged the motor that when these sudden overloads come on the system, the motor speed is reduced, and this permits the flywheel to take up the overload. This system has been worked out in great detail, and the Company has designed an absolutely automatic arrangement by which the electric slip of the induction motor can be adjusted to the load variations of any particular mill, thus ensuring that full advantage is taken of the stored energy in the flywheel, and at the same time keeping a steady load on the motor. This is a point worthy of particular attention, since it is the constant-speed characteristic of the ordinary alternate-current induction motor which has hitherto prevented its general adoption for rolling mill service.

Speed-Reducing Gear.

In considering the application of electric motors to the driving of shafting or isolated machines one is often confronted with the difficulty of keeping the driving and driven pulleys within reasonable limits without having recourse to costly slow-speed motors on the one hand or expensive and cumbersome countershafting on the other. To meet the above-mentioned difficulties the Pilkington-Gibbs reducing gear has been devised. This gear consists of a combination of belt and spur gearing in conjunction with devices which enable the belt-tension to be easily adjusted, and which permit the motor to be fixed in the most convenient position.

The spur wheels are carried by and enclosed within a gear case, thus remaining always in the correct relative positions, and when once fitted cannot become disturbed.

The gear case enclosing the spur wheels is journalled on the driven shaft, to which one of the spur wheels is keyed, the other wheel (or pinion) being fixed on a countershaft, supported in long bearings in the gear case. This countershaft carries the belt pulley.

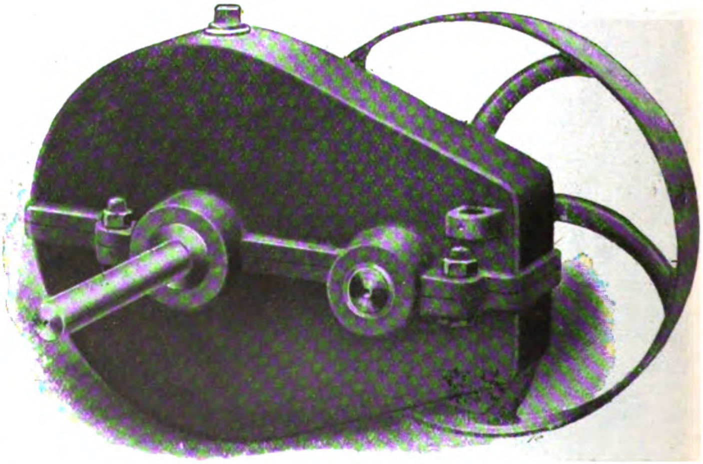


Fig. 1. The Pilkington-Gibbs Reducing Gear.

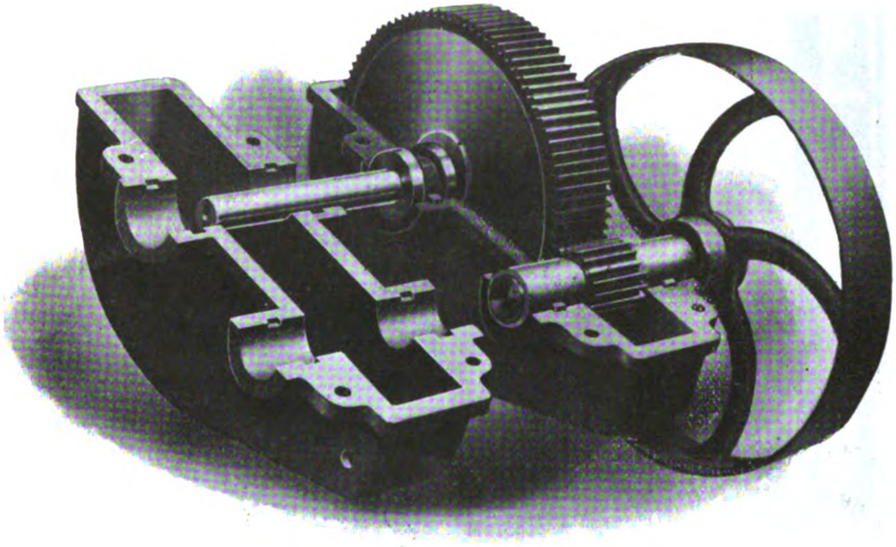


FIG. 2. INTERIOR VIEW OF PILKINGTON-GIBBS REDUCING GEAR.

A swinging motion of the gear case is thus obtainable, enabling the driving belt to be tightened or slackened without disturbing the proper meshing of the spur gear. It will be readily understood that no matter into what position the gear case is swung the spur wheel and pinion remain correctly in gear.

The definite position of the gear case, and consequently the belt tension and direction of the belt drive, is determined by the tension device, which generally consists of a stay rod attached to the gear case at one end and supported by any convenient fixed bracket at the other end, which is generally screwed and provided with a combined handwheel and nut. The pull of the belt being taken up by the tension device, the driven shaft is relieved of bending stresses, permitting the use of a short endless belt, which can always work at its most effective tension, with a consequent gain in efficiency and power transmitted.

The gears, which are made in single and double reduction, are stocked in seven sizes ranging from ¼h.p. to 80h.p. They are manufactured by Mr. E. Dewhurst, at the Mount Street Works, Preston, who is the sole maker, and from whom full particulars and description can be obtained by anyone interested.

The "Premier" Tandem Two-Cylinder Positive Scavenger Type Engine.

SOME particulars of several types of the well-known "Premier" gas engines appeared in the last number of THE ELECTRICAL MAGAZINE. The following are further details of the scavenger arrangement adopted.

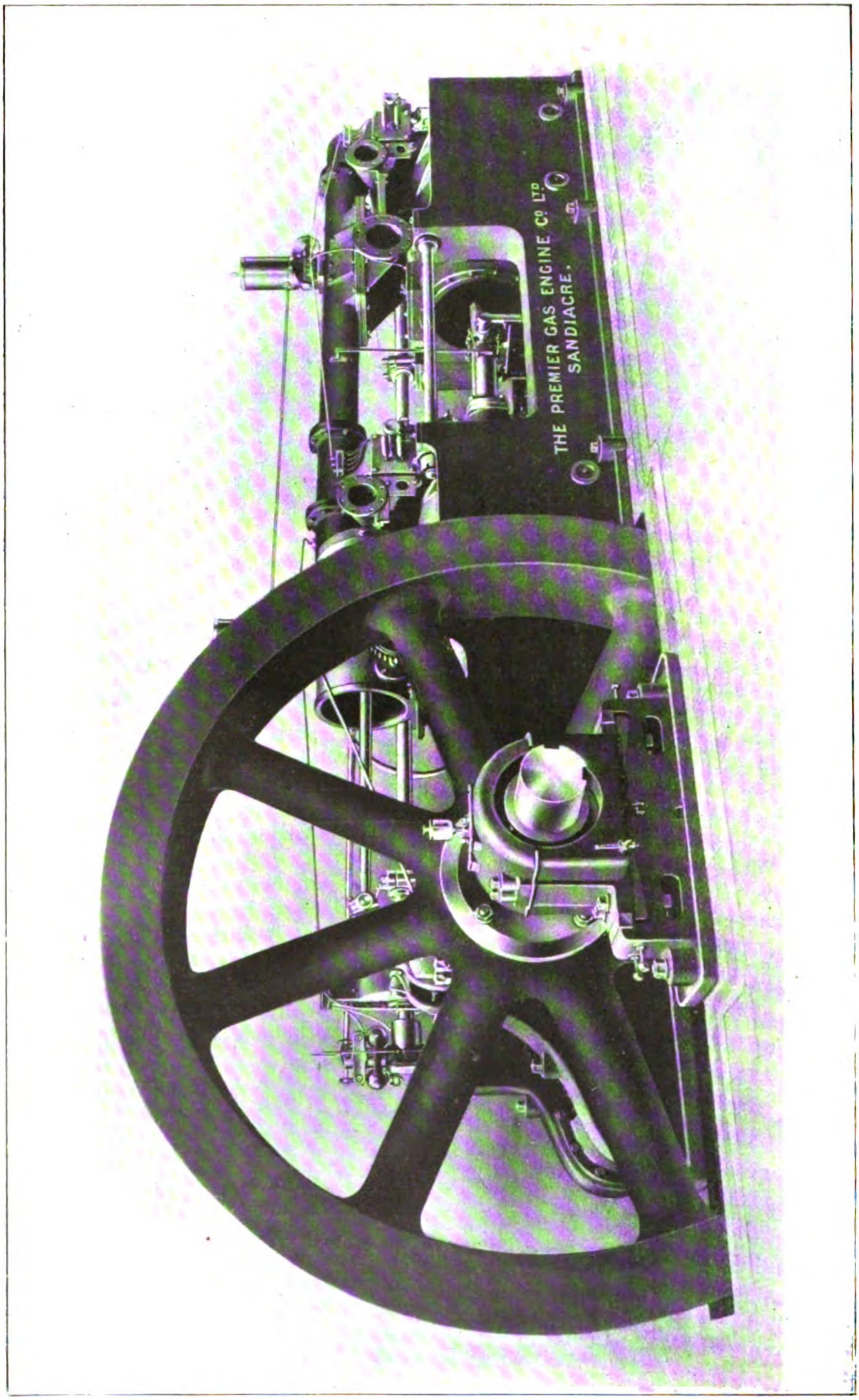
This engine works on the well-known four-stroke cycle, that is to say, in each cylinder the cycle is completed in the following four strokes:—1st, suction; 2nd, compression; 3rd, explosion; and 4th, exhaust.

These operations are caused to alternate in the two cylinders as follows:—

Front Cylinder.		Back Cylinder.
Suction	Out Stroke ...	Explosion
Compression ..	Back Stroke ...	Exhaust
Explosion ...	Out Stroke ...	Suction
Exhaust	Back Stroke ...	Compression

from which it will be seen that on every out stroke there is an explosion and for each back stroke a compression, the effect of which is to produce smooth and silent running, because there is no reversal of pressure on the connecting rod bearings and consequently no knocking at these joints.

In addition to the above there is a positive scavenging operation effected as follows. Towards the end of the exhaust stroke the



THE "PREMIER" TANDEM, TWO-CYLINDER, POSITIVE SCAVENGER TYPE GAS ENGINE.

admission valve is opened, and air compressed in the passages behind this valve flows into the combustion chamber or clearance space, driving out before it through the exhaust valve the products of combustion resulting from the previous explosion.

The air for this purpose is compressed to a pressure of about 3lb. per square inch before the opening of the valve by a pump placed horizontally above the engine, and operated by means of a rod jointed to the big end of the main connecting-rod. After the admission valve opens, the pump piston continues its motion and keeps up the steady flow of air, and this action is continued till the crank has passed the dead centre and the suction stroke has been commenced. The exhaust valve is now closed, and the pressure in the air pipe having fallen below atmospheric pressure, air is drawn in through an automatic inlet valve, part of this air passing to the engine cylinder and on its way mixing with the gas admitted by a separate valve, and part going to the scavenging air pump, the piston of which is also moving forward.

The same action is repeated during the next revolution, but the front cylinder takes the place of the back, and vice versa.

Thus each cylinder is scavenged after every explosion; that is, the foul gases are swept out by a charge of air forced positively through the combustion chamber. These foul gases, which in ordinary engines are very hot, are the cause of "back-firing," which is practically unknown with this engine. The one air pump serves to scavenge both engine cylinders, and as there is only one additional valve, namely, an automatic air inlet valve, the engine is very little more complicated than an ordinary four-stroke engine without the scavenging arrangement.

The valve gear is also novel and marks a new departure. The admission and exhaust valves are placed in the cylinder ends, and open directly into the cylinder, and thus there is no broken surface, port, nor passage to break the simple outlines of the wall containing the explosive mixture and add to the cooling surface, and consequent loss of heat.

These valves, being horizontal and parallel to the lay shaft, are operated by grooved cams on the latter. These cams not only open the valves, but also close them in a positive manner, and thus the use of springs is done away with, and this source of annoyance and trouble removed.

"Tubolite."

Considering the proved advantages which the straight length of carbon filament enclosed in an exhausted tube exhibits over the standard looped filament in a bulb, it would seem that the latter type of incandescent electric lamp is destined to give way more and more to the former as the respective merits of the two become more generally known. The expressive term "Tubolite" has been applied to the electric lighting system controlled by The Linolite Company, Westminster. The illustrations Figs. 1 and 2 show very clearly the general arrangement of the system. Briefly it consists of a series of straight or tubular incandescent lamps, placed end to end in a trough-shaped reflector of polished aluminium. The lamps themselves consist of a straight carbon filament in a glass tube. The filament has a small spiral bend in the centre to take up expansion, and it is stretched between the terminals fixed in vitrified caps at the tube ends. The poles of the lamp circuit being at opposite ends of the tube at once ensures the highest degree of

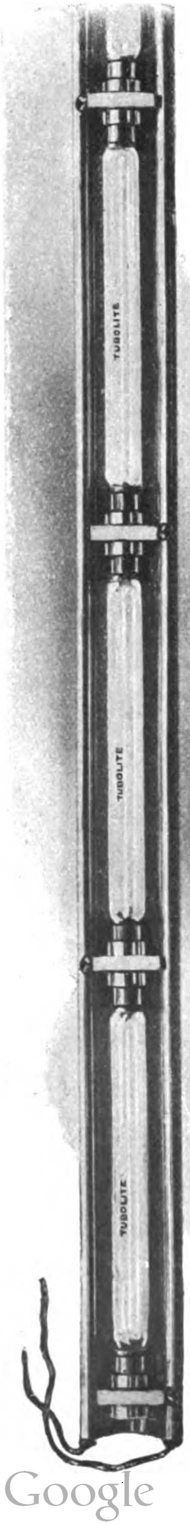


Fig. 1. General Arrangement of "Tubolite" System

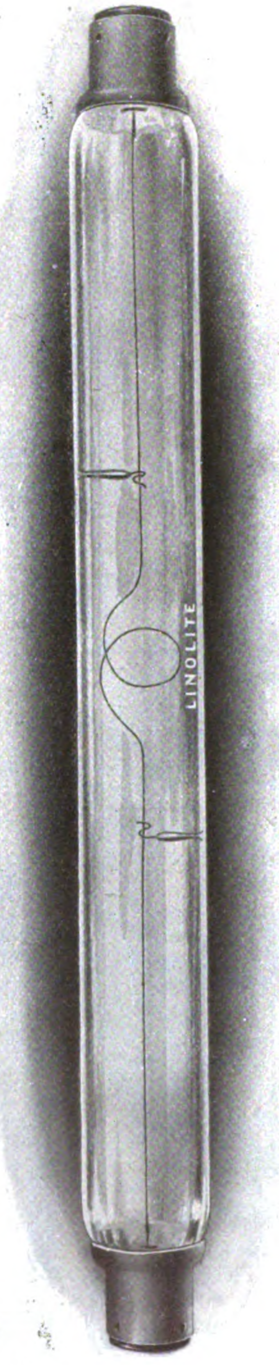


FIG. 2. LAMP OF "TUBOLITE" SYSTEM. FULL SIZE

insulation and safety so far as the lamp contacts are concerned. The bridge pieces containing the socket-type lamp-holders are made of porcelain in one piece, the channels for the leading-in wires being so disposed as to render the wiring of the system a simple and straightforward matter and preventing the possibility of any stray strands of the flexible wire causing faults. The use of a porcelain base for insulation in the lamp-holders renders the system perfectly suitable for installation even in damp places, and practice has shown that for such conditions the "Tubolite" exhibits decided advantages over other systems. Every part used is manufactured to exact gauges and perfect duplication in this respect has encouraged the wide-spread adoption of the system, not less than fourteen miles of "Tubolite" being in use.

Until recently the standard lamp was one of 12c.p. rated at 45 watts; but the modern tendency towards increasing the intensity of the lighting centres, doubtless due to the new types of metallic filament lamps now becoming so popular, has led the Linolite Company to introduce a 32c.p. lamp rated at 120 watts. The general dimensions of the lamp and reflector are of course increased, but they are proportional to those shown in Fig. 2, which is a full-size reproduction of the 12c.p. standard lamps.

It will at once be understood that for special lighting services, such as the illumination of pictures, show-cases, shop windows and so on, the "Tubolite" system possesses unique advantages, inasmuch as it lends itself to outlining the field to be illuminated and can be hidden away from the direct line of sight. It is when one realises that with this advantage the system offers such superior electrical efficiency as to permit of the use of its further reflected light that the field of its application is at once widened to embrace all classes of internal illumination.

Without entering further into this question of efficiency it will be sufficient to refer to the illustration Fig. 3, in which direct comparisons between an ordinary 16c.p. lamp with opal reflector and a 16c.p. "Tubolite," or "Linolite," as it is termed on the diagram, with aluminium reflector, are represented graphically. These curves show the results of tests made in the electrical laboratories of the Municipal School of Technology, Manchester. In general the results show

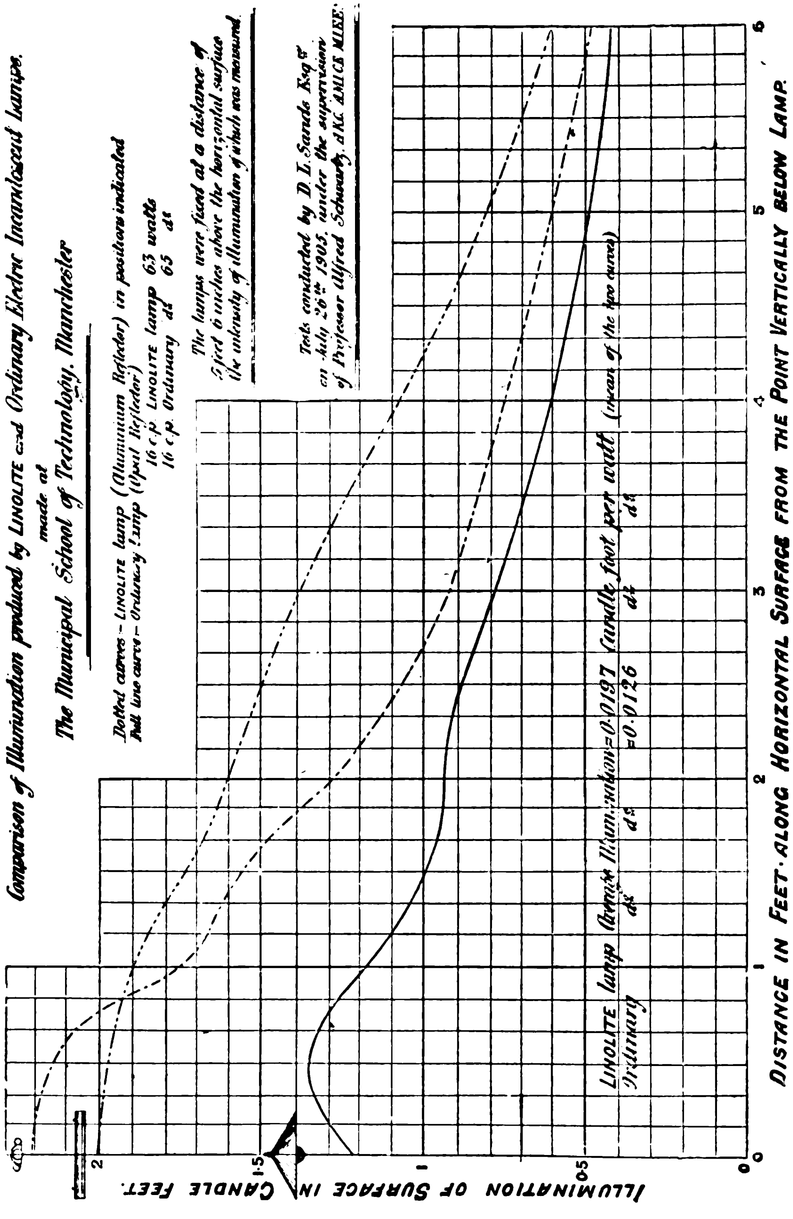


Fig. 3. Comparative Tests of "Tubolite" System with ordinary Incandescent Electric Lamp.

that the "Tubolite" system will with the same energy consumption illuminate an area with about 57 per cent. more light than an ordinary glow lamp. It will therefore be seen that a room can be lighted more economically in the best of methods, viz., using reflected light, giving perfect diffusion, by means of "Tubolite" than by direct ordinary glow lamps, since the light absorption of a white ceiling used as reflector would not in any case exceed 25 per cent. So far as the lamps themselves are concerned they give a life exceeding 1000 hours, and tests have proved that the falling off in candle power at the end of 1000 hours' run averages only about 14 per cent.

The makers have recently advised a reduction in the prices as a result of improved methods of manufacture and increasing outputs. It will be found that on this score also the system is at no disadvantage.

Small Electric Furnaces.

It is the claim of the Phœnix Electric Heating Company, Ltd., whose works are in London, that they have supplied more industrial electrical heating apparatus than all the other electric heating apparatus makers, not only English but those of the United States and Europe, put together. The belief of the Company is that the future of electric heating rests more with its application for industrial than for domestic purposes. An inspection of the new catalogue issued by the Phœnix Company will prove a surprise to those who believe that progress is slow and little is being done in the way of adapting electric furnaces and heaters to trade uses. The immense range covered by the apparatus listed certainly tends to substantiate the makers' claim to pre-eminence in this field of electrical manufacture. The several illustrations reproduced here show typical examples of the work turned out and indicate that the first aim of the designers has been to supply apparatus which shall be essentially convenient and familiar to the worker. The apparatus includes drying plates and rollers for printers, laundrymen, metal decorators, photo-print dryers, lacquering and japanning processes.

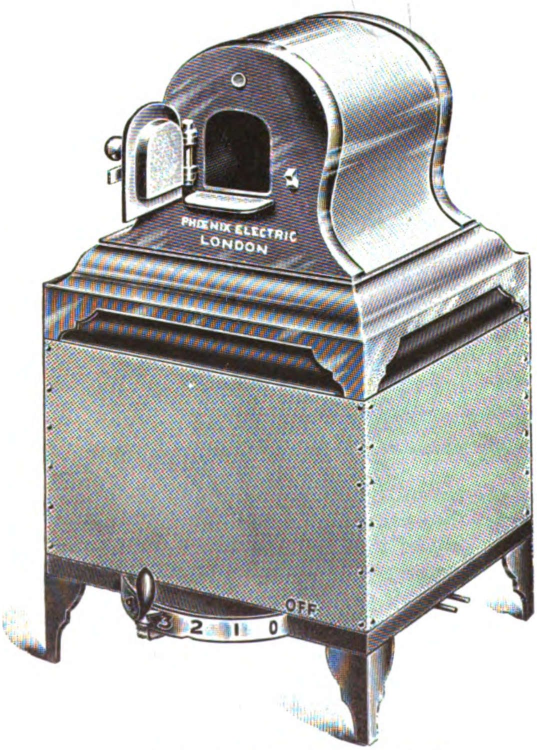


Fig. 1. Electric Muffle Furnace.

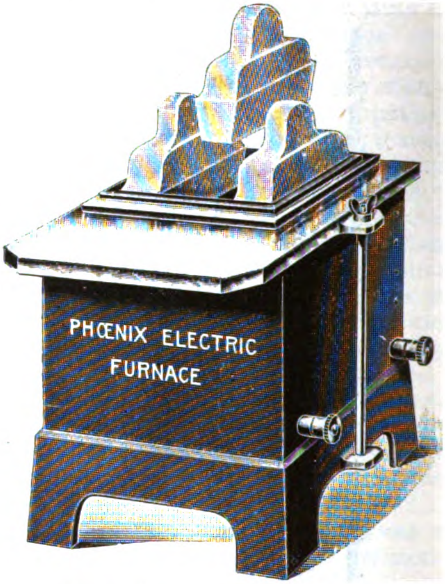


Fig. 2. Electric Crucible Furnace.

Electric muffles and crucible furnaces are a distinct speciality. Fig. 1 shows a muffle furnace specially suitable for and largely used by engineers for hardening tools, by manufacturing chemists and assayers.

Crucible furnaces, as shown in Fig. 2, are made to take any size of crucible from 1in. by 1in. up to 24in. by 24in., giving any required heat up to 3000deg. F., which can be regulated to suit requirements

As indicating the economy of these furnaces it is said that the type of muffle shown in Fig. 1 will with a consumption of 200 watts at starting and only 100 watts afterwards, become red hot in five minutes. Taking the cost of current at one penny per unit it will take only $\frac{1}{60}$th part of a penny to obtain this result, a result not obtainable by any other means of heating. Fig. 3 shows an enamelling furnace largely used by enamellers and painters on glass. Fig. 4 illustrates a blower, by means of which either cold air for ventilating or hot air for warming purposes can be obtained.

A tempering, annealing, and hardening furnace as suitable for coils of wire, discs or rings of metal is shown in Fig. 5.

There are many other important heaters supplied as standards; these include vulcanizing stoves, ovens, radiators, branding

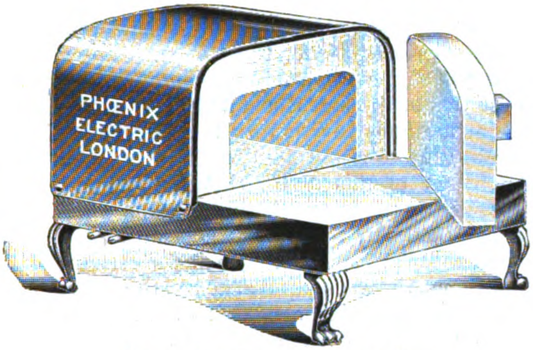


FIG. 3. ELECTRIC ENAMELLING FURNACE.

tools, soldering appliances and, of course, all apparatus for domestic purposes from the flat-iron to the most complete cooking ranges. The many orders in hand for special articles include branding irons suitable for branding anything from a cork to a packing case and for marking stoppers; automatic soldering irons for tin canisters; paraffin melting vats for makers of waxpaper and candles.

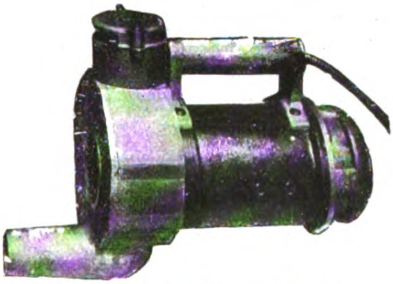


FIG. 4. ELECTRIC HOT-AIR BLOWER.

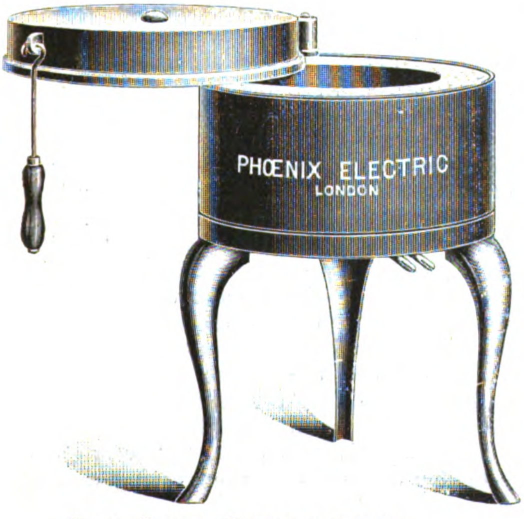


FIG. 5. ELECTRIC TEMPERING FURNACE.

Exhaust Steam Turbines.

Two remarkable installations of exhaust steam turbine power generating plants have been recently completed by the Bergmann Company in Germany. One of them, that of the Hoesch Iron Works, Dortmund, consists of two 500kw. steam turbines, 750h.p., 1500 revolutions per minute, both coupled to direct-current generators of 500 volts.

These turbines are supplied with steam from a 5000h.p. reversing rolling mill engine, and develop all the power required for driving the motors, operating the live roller gear, and also supply energy to two 500h.p. wire rolling mill motors. The power obtained from the exhaust steam in this installation thus exceeds 1500h.p. for practically no cost at all, except the interest on the capital outlay of the plant.

The second installation is of exceptional interest in that it is probably of a unique character; it is in operation at the iron works at Remscheid. At this works there are fifteen steam hammers of various sizes for forging rounds and squares. All the exhaust pipes from these steam hammers are lead into one main pipe, which in turn leads to the turbine. This turbine is of 500kw. capacity, 250 volts, 750h.p., 1500 revolutions per minute. The steam enters the turbine at atmospheric pressure, or in any case the pressure does not exceed, when all the hammers are at work, 3lb. per square inch.

The whole of the electrical power in these works for driving the various machine shops, &c., is obtained from the exhaust steam from these hammers, and the economy which results from this method of generating power is of course enormous. They have been able to shut down two large boilers entirely, which formerly supplied steam for the reciprocating engines, driving the dynamos.

Messrs. Marples, Leach & Co., Ltd., handle the manufactures of the Bergmann Company in this country and are prepared to undertake complete installations of this kind, including the supply, delivery, and erection of the exhaust steam turbo-generators, condensing plant, and all electrical gear. There are numerous works in this country where exhaust steam plants could be put down with the certainty of great economies resulting therefrom.

Electric Heating to Moderate Temperatures.

ALTHOUGH the use of electricity as a heating agent in the production of steel, &c., has lately much come to the fore, it is often overlooked that there are many possibilities of utilising the electric current conveniently and economically for the production of moderate temperatures.

The idea that electric heaters are unreliable articles, too fragile for workshop use and continually going wrong, was formerly only too well founded and still represents unfortunately the state of affairs with certain systems ; yet, as in every other branch of electric engineering, sound progress has been made, and it is now possible to obtain articles the electrical and mechanical design of which is such as to fit them thoroughly well for hard everyday use in the workshop.

The system which forms the subject of these notes has now been well known in this country for over seven years, and it was particularly owing to its sound mechanical features that the "Elektra" was awarded—on the last occasion that such a competition took place, namely, at the Electrical Exhibition at Olympia—the first prize. In this connection it ought to be remembered that the jury consisted almost exclusively of central-station engineers, with whom strength and mechanical design counted more than shape and style. The "Elektra" system, briefly described, consists of a special alloy wire embedded in a special clay mixture which is so selected as to have the same co-efficient of expansion as the wire. In this way a "brick" is formed which is dried and afterwards burned in a kiln. This "brick" as a rule forms the core of a mould into which the iron shell is run, and the latter on cooling shrinks upon the core, thoroughly protecting the latter and transmitting the heat generated in the core most perfectly to the iron shell. In this way not only is perfect protection assured, but the mass of brick and iron possesses a considerable heat inertia which is most useful. By this construction it is possible to deal with the very largest articles and one is not confined to small hot plates, &c.

Messrs. Isenthal & Co., who handle this system in England, have lately supplied several very large heating plates for use in steel works for tempering purposes, likewise others for the laboratory, and also soldering irons, &c. To the progressive manager of a steel works many other uses for such appliances will suggest themselves as soon as he is aware that such plant is available. It is now a comparatively easy matter to obtain temperatures up to about 400deg. C. in an electric heater of this type without in any way endangering the life of the elements; a series of tests made by the Post Office authorities conclusively proved that, even under extreme conditions, the life of appliances on the above system is far superior to that of others in which the heating element itself consists of bare wires, wires in enamel or separated with thin sheets of mica. Although not directly touching upon its application for steel and iron works, it may be mentioned in passing, as illustrating the large scale on which electric heating is now being commercially applied, that "Elektra" heating has been applied to fairly large steam producers heated (paradoxical as it may seem) electrically, and to large bakers' ovens, cauldrons, and such like heavy industrial services.

◆

Large Motor for Rolling Mills.

MESSRS. Marples, Leach & Co. have secured an order for the supply, delivery and erection of a high-tension two-phase alternating-current induction motor for driving two 10in. and one 8in. mills at the works of Messrs. Samuel Osborn & Co., Ltd., Sheffield.

This motor is being wound for the high-pressure distributing mains of the Sheffield Corporation Electric Supply Department at 2000 volts, two-phase, 50 periods. The motor is normally rated at 350b.h.p., but is capable of sustaining very considerable overloads for short periods without injury; it is being provided with wound rotor, brush-lifting and short-circuiting device, by means of which the wear and tear on the brushes and slip-rings is reduced to a minimum.

In order to enable the flywheels to take their proper share of the work, the rotor is being provided with a bank of resistances which rotate with the machine, thus allowing a considerable percentage of slip when the load exceeds the normal.

This is the largest motor which has yet been placed upon the Sheffield supply mains, and it is anticipated that very great economy will result in the working of the mill.

Rotary Transformers.

THIS is essentially the age of the alternating-current supply system; the polyphase current has demonstrated its advantages so thoroughly in all power-requiring industries and as superior in every way from the supply company's point of view, that it devolves upon the customer to produce for himself any direct current that he may desire. For such purposes as accumulator or ignition-cell charging, for electro-chemical processes and electro-medical treatments, a small source of direct current is essential, and the demand for small transformers to generate low-voltage direct current from the public supply service led the Crypto Electrical Company, who have long been known as specialists in the manufacture of small dynamo-electric machines, to make a standard line of such machines.

One of these machines is illustrated in Fig. 1. This transformer set consists of a motor wound for alternating current and mounted in the same frame with a continuous-current dynamo. The motor can be supplied wound for any voltage and periodicity, single-phase, two-phase, or three-phase, and the dynamo has an output of 100 watts; the standard winding for the direct-current side is 15 volts, 6 to 7 amperes, at which output the machine is capable of charging nine motor-bicycle accumulators at two amperes charging rate, or four to six motor-car accumulators at 3½ to 5 amperes. With this machine the current consumption is at the rate of about one unit per three hours' run at full load. Its principal dimensions are: length, 15in.; height, 13in.; width, 11in.; whilst its weight is 72lb. This little transformer has been on the market for about three years, and there are already some hundreds in use in practically every town in this country where the supply is of the alternate-current system. The makers further state that they have quite a considerable demand for this machine from foreign countries.

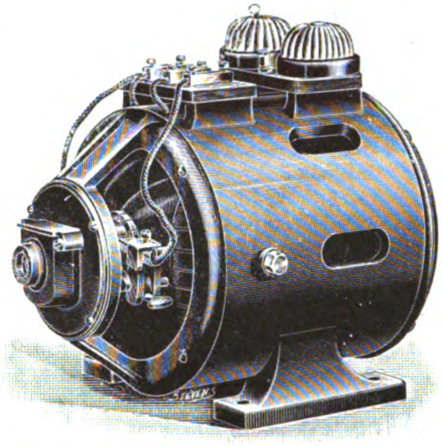


FIG. 1. CRYPTO A.C. TO D.C. TRANSFORMER.

Whilst it is essential to have some transforming or rectifying plant for producing direct current from an alternating-current supply, it is also, for reasons of economy and convenience, preferable to introduce a transforming machine where a low-tension direct current is to be drawn from the ordinary public direct-current supply. The Crypto machine (illustrated in Fig. 2) serves this purpose. It is particularly suitable for garage work; the primary side is wound for any voltage up to 250 volts, and the secondary for 15 volts 7amp.

The cost of charging six accumulators, at a charging rate of 3.5amp., by means of this transformer, comes out at 4d. for an eight-hour charge, whereas the same accumulators would cost more than 1s. 3d. when charged in the usual extravagant way through lamps or other series resistance. Even these figures do not, however, truly represent the full saving, owing to the current used by the transformer being charged up at the power rate, which is usually 2d. per unit or less, whereas the lamp rate is never

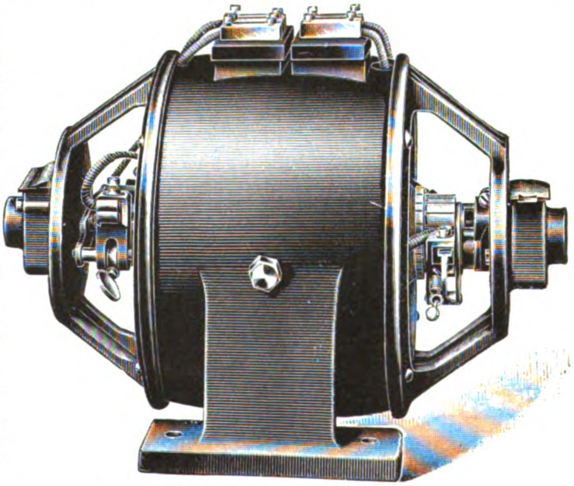


FIG. 2. CRYPTO D.C. TO D.C. TRANSFORMER.

less than 4d. per unit, and is often as high as 6d.

The Crypto Company also build two-machine transformer sets, and as makers of direct-current and alternate-current motors of sizes from ⅙h.p. up to 10h.p. or 15h.p., have established a very considerable reputation. Of late years the company has also done quite a considerable business in the manufacture of small alternators, from ½kw. up to 10kw., for electro-medical, X-ray, and wireless telegraph purposes.

“Sirocco” Induced Draft.

Good draft and high chimney stacks were formerly considered as practically synonymous terms; but good chimney draft also implies the requirement for high temperatures in the escaping gases from the boiler furnaces, and in practice it has been found more economical to allow these waste gases to pass into the chimney base at about 500deg. F., and to accept the loss of heat which this represents rather than attempt any further absorption of this heat either by the boiler or by economisers, as so doing necessarily reduces the draft power of the chimney, and involves defective combustion and non-development of the full heat-producing capacity of the fuel, from which cause the loss of heat is often very much greater than any saving of heat that could possibly be effected from the waste gases.

Coal of good quality will yield about 14,000 British thermal units of heat per lb., when the gases arising therefrom are fully oxidized into carbonic acid (CO_2); but if the combustion be imperfect, through deficient or defective admixture of oxygen with the products of combustion, and to such an extent that these gases escape from the furnace as carbonic oxide (CO), then only about 4500 units of heat will be developed from the fuel. Consequently, from a maximum heating capacity of say 14,000 units per lb. of coal, any intermediate reduction of this heat-yielding capacity may occur down to as low as 4500 units, according to the amount of carbon which may be deficiently oxidized. On the other hand, if air be admitted in too great a quantity, the temperature of the gases is reduced by such excess of air and the effective steam-producing power of the coal equivalently diminished.

Different qualities of fuel require different draft powers or air supply, and obviously, for economical results, the means by which the draft is produced must be capable of adaptation to varying circumstances. The effective draft power, in inches of water, required at the furnace to burn efficiently various qualities of fuel at the rate of about 20lb. per square foot of firegrate per hour, is approximately as follows:

Description of fuel.	Draft power at back of furnace in inches of water.
Wood	0.2 to 0.3
Ordinary steam coal	0.4 ,, 0.6
Slack, ordinary	0.6 ,, 0.8
Slack, very small	0.9 ,, 1.1
Fine anthracite	1.0 ,, 1.5

Assuming that the furnace gases pass to the chimney at 500deg. F., the draft powers (expressed in inches of water) produced by chimneys of different heights, and in fairly calm weather, are as follows:

Height of chimney above level of firegrate.	Suction at base of chimney. in inches of water.	Approximate effective suction at back of furnace.
50	0.364	0.218
80	0.583	0.350
100	0.729	0.438
150	1.095	0.660
200	1.459	0.875
250	1.825	1.095
300	2.189	1.314

From the foregoing tables it will thus be seen that to burn wood fuel at the rate of 20lb. per square foot of firegrate per hour requires a chimney of at least 50ft. high, and that ordinary steam coal, for its efficient combustion at the same ratio, requires the draft power due to a chimney of 100ft. to 150ft. in height, while for various qualities of slack, chimneys of from 150ft. to 250ft. high would be required, and for fine anthracite the chimney should be from 250ft. to 300ft. in height.

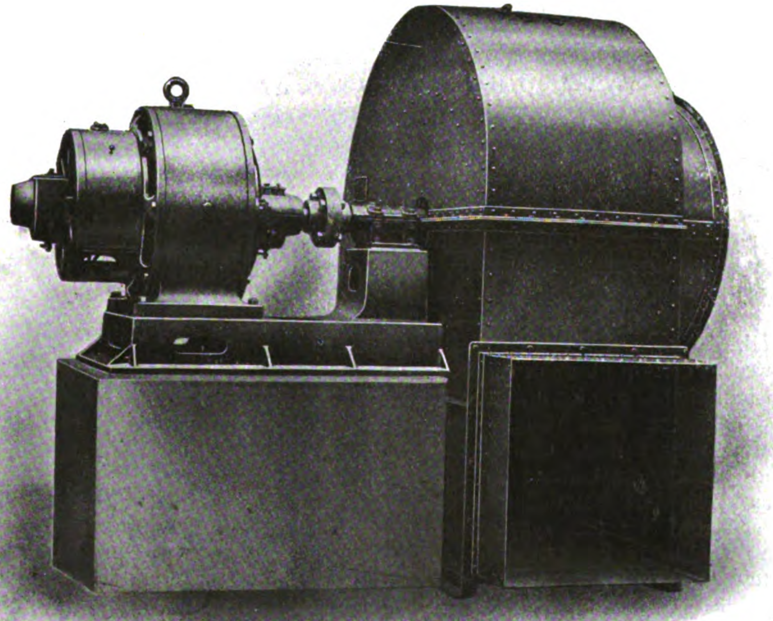
As a matter of fact, with chimney draft the user is practically limited to the employment of the particular quality of fuel which will give the desired rate of combustion with the fixed strength of draft due to the height of the chimney to which the boiler is connected.

But the calorific capacity of high grades of coal is much lower, in relation to their cost price, than that of the low grades, provided the latter are burnt efficiently under a suitable strength of draft; hence, for a given duty in steam production, the cost for coal will be less if low grades are used, and their combustion efficiently obtained (though a larger weight may be burnt), than if high-grade qualities have to be employed owing to the available strength of draft being insufficient for the proper combustion of low grades.

Good chimney draft, suitable for the combustion of inferior grades of coal, is, however, a serious consideration, as chimneys from 200ft. to 300ft. high are not only few and far between, but in many cases are impracticable, owing to poor foundations, or to municipal regulations, even if they were not so expensive in regard to first cost as to be almost prohibitive.

Fan draft meets the difficulty, not only as to practicability but also as to first cost, while in addition it allows of the heat of the waste gases from the fuel being utilized so fully in the boilers and by economizers and superheaters, that the proportion of loss of heat carried off by the waste gases may be reduced to a minimum, as it matters not how cool these are when they reach the fan, the draft power which it produces being controlled simply by the speed at which it is rotated; and the saving of heat which can be effected from the waste gases by the employment of fan draft far more than counterbalances the total power taken to drive the fan. The "Sirocco" fans made by Messrs. Davidson & Co., Ltd., of Belfast have advantages over fans of other types, in that for a given duty they are smaller in size and lower in cost price, and at the same time absorb less power. They run noiselessly, and are adaptable to confined spaces where other centrifugal fans for a similar duty could not be placed. A suction draft of 1in. to 2in. on the water-gauge (which is easily obtained with "Sirocco" fans) is equal to the draft power of chimneys from 150ft. to 300ft. in height, and with the fan, if there is no existing chimney installation, a short stack of just sufficient height to deliver the gases above the factory roof is all that is required.

By the employment of these fans, users have been enabled to burn low-grade coals,



"Sirocco" Under-cast Induced Draft Fan, direct coupled to Electric Motor whereby, although for the same duty a greater quantity is usually required, a saving of as much as 25 per cent. has been effected in the coal bill over a given period, as compared with a similar period when employing chimney draft prior to using the fan. The more important claims of the makers of the "Sirocco" fans are, as compared with other types of fans, greater volumetric capacity, and for a given duty less bulk; higher mechanical efficiency, requiring less horse-power for the work done; at a given speed a higher pressure or suction; where speed is restricted a smaller size of "Sirocco" fan can be used than of any other make for a given duty; cheaper in initial cost, and as they require less horse-power for the work, the cost of running is also reduced.

A very large number of "Sirocco" fans for induced draft on boilers have been supplied to the chief electric power stations, as well as to many leading and well-known industrial concerns and mines, both at home and abroad, all of which are giving highly satisfactory results.

Reports from users show that, in many instances, the employment of "Sirocco" fans has not only shown economical results, and much improved the steaming capacity on boilers where the chimmey draft had previously been defective, but also on boilers which already had fairly good chimney draft.

"Sirocco" fans may be driven by belt or rope, or by direct-coupled steam engines or electric motors. The illustration on the preceding page shows how extremely compact is the arrangement of the direct-coupled electrically driven set. They are fitted with water-cooled bearings when considered desirable, and strongly constructed so as to resist the corrosive action of the gases passing through them at high temperature. In large electric-light stations, where the demand for extra power at certain hours of the day, and more particularly the sudden and unexpected demands in dark and foggy weather, constitute a very serious difficulty where unassisted chimney draft alone is employed, this difficulty, it has been found, can be entirely obviated by the employment of these fans which can be put into service immediately and which are equally applicable to one single boiler or to large batteries. Owing to their compact form and well-balanced running they are readily adaptable to suit the existing conditions of any boiler-house and its plant.

The World's Great Mining Exhibition.

With the near approach of the opening date of the forthcoming World's Great Mining Exhibition to be held at Olympia during the last three weeks in July (a preliminary notice of which appeared in the last issue of THE ELECTRICAL MAGAZINE), readers will be interested to know the names of a few of the leading firms taking part in this most representative exhibition, which are as follows:—

Head, Wrightson & Co., Ltd.
Hadfield's Steel Foundry Co., Ltd.
Hardy Patent Pick Co., Ltd.
Geo. Cradock & Co., Ltd.
Edgar Allen & Co., Ltd.
Lowca Engineering Co., Ltd.
Stewarts & Lloyds, Ltd.
Dick Kerr & Co., Ltd.
Galloways, Ltd.
Haniel & Luegg.
Heinrich Lanz.
Meguin & Co., Ltd.
Diamond Coal-Cutter Co.
Mavor & Coulson.
Wolf Safety Lamp Co.
Ingersoll Rand Co., Ltd.
Fraser & Chalmers, Ltd.
Gibbons Brothers, Ltd.
Wilfley Mining Machinery Co., Ltd.
R. H. Longbotham & Co., Ltd.
Browett, Lindley & Co., Ltd.
Andrew Barclay, Sons & Co.
Heenan & Froude, Ltd.
Ernest Scott & Mountain, Ltd.
Bullivant & Co., Ltd.
Holman Brothers, Ltd.
Davidson & Co., Ltd.

As the exhibits of these firms alone comprise everything up to date in the matter of coal cutting, conveying, hauling, washing, screening, blasting, drilling, &c., &c., it will readily be gathered how large is the scope of the Exhibition.

The organiser is Mr. H. Greville Montgomery, M.P., of 43, Essex Street, Strand, W.C.

Electric Driving in Cotton Mills.

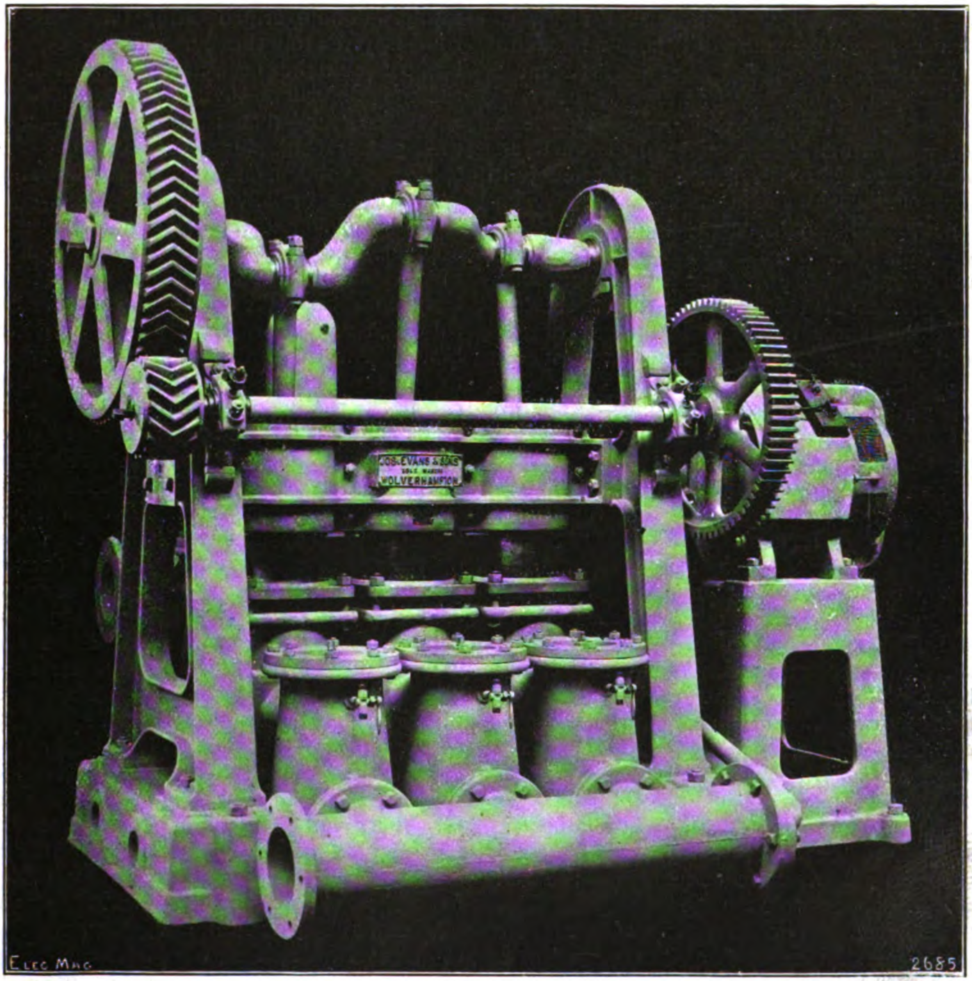
Messrs. Marples, Leach & Co., Ltd., have secured the contract for the complete equipment of the new mill being erected by the Tyne Ring Spinning Co., Ltd., at Littleborough, near Manchester.

This equipment consists of a complete generating plant, including a 1200kw. three-phase steam turbo-generator at 50 cycles. 400 volts, a Pilot lighting set, condensing plant with electrically-driven pumps, two 400h.p. three-phase induction motors at 485r.p m., two 100h.p. motors at 360r.p.m., one 50h.p. motor at 360r.p.m., and a number of smaller motors.

The larger motors will be direct-coupled to the driving shafts on the different floors, while the smaller ones will be connected by ropes or belts to the machine which they have to drive.

An elaborate engine room switchboard is being provided for controlling the whole of the power and lighting circuits in the mill, the main lighting circuits being divided into three sets, being equally balanced over the three phases, and will be at 230 volts.

The contract includes the supply, delivery and erection of the whole plant, including the wiring throughout. This section of the work, however, Messrs. Marples, Leach & Co., Ltd., will sub-let to local contractors.



10in. by 12in. Three-throw Pump, electrically driven, as supplied to Messrs. Beardmore & Co., Ltd., Parkhead Works, Glasgow, by Messrs. Joseph Evans & Sons (Wolverhampton), Ltd.

Electric Absorption Dynamometer.

The Morris & Lister patent eddy current testing brake combines the well-known advantages of the use of electricity as a braking force with a well-designed and convenient mechanical arrangement. This brake was designed to meet the demand for a testing brake which should be at once accurate and convenient in handling and adjustment, and which would be free from the wear and tear and the objectionable heating associated with the use of a band or rope brake. When used for the continuous absorption of even very small powers, band or rope brakes are either of unwieldy size or else the brake pulley must be water-cooled, with the usual result of splashing and generally dirty and unpleasant conditions. Air is in most cases a more suitable medium than water for carrying away the heat generated in absorption tests on all motors except those of large sizes. It is claimed for the brake illustrated that for accuracy and convenience it is much superior to any other type of absorption dynamometer on the market for testing motors up to 50b.h.p. One of the particular advantages of the brake is that it exerts a retarding force nearly independent of the speed when run at or near its rated speed. The brake lever thus floats steadily even when the torque is fluctuating—a feature which renders the appliance very suitable for the testing of petrol motors.

Reference to the illustration, Fig. 1, will show the general form and construction of the brake. It consists of two wrought-iron discs, faced with thin copper, each mounted on a cast aluminium spider. These are made fast, one at either end of a sleeve which is arranged for keying to the shaft of the motor under test. Riding loose on this sleeve and between the two discs is an aluminium casting carrying a number of electromagnets wound to have alternate polarity. These magnets consist of well-ventilated coils on circular cores fitted with pole pieces. The thin copper is secured to the iron discs by a large number of rivets all over the surface, and the rim of the copper which projects over the edge of the iron is spun over in order to give increased stiffness. The iron serves as a path for the magnetic flux which has to cross through the copper as it passes over the gap from the poles. To the outside of each iron disc cooling vanes are riveted, which dissipate the heat generated by the induced eddy currents in the rotating discs. When the motor is running the magnetic flux in traversing the moving copper induces eddy currents which absorb the energy of the motor in the heating of the discs. At the same time the flux tends to drag round the magnet system and levers. By suitably adjusting the exciting current of the magnets the lever floats. The power is then given by—

$$\text{B.H.P.} = \frac{\text{Torque in lbs.-ft.} \times \text{R.P.M.}}{5250}$$

The brake is supplied for continuous rating. The overload rating for short-time runs is given on the curve (Fig. 2). The brake should be used as far as possible in the neighbourhood of its rated speed. For special speeds—that is, varying by more than 50 per cent. above or below the rated speeds of the standard brakes—modified types of the brakes can be supplied.

With this brake there are no sources of appreciable error. Any friction occurring in the central bearing is represented as torque on the brake lever—the brake acting to that small extent as an ordinary friction brake. Air friction is similarly transmitted to the lever by means of the outer guards carried by the floating system. The magnet system and levers float perfectly freely on the revolving central bush, quite irrespective of the friction occurring there. This applies even to the smallest loads. The loads can be easily and accurately adjusted by means of the rheostatic control of the exciting current; an electric motor, for example, can be tested for efficiency at six or eight loads in a few minutes. Even with a fluctuating effort the brake exerts, at or near its normal speed, a retarding force practically independent of the speed, so that the lever remains steady. After the first few minutes' run, while the brake discs are heating, the load will keep quite constant for hours without attention, provided that the exciting current is kept constant. By careful design in the proportioning of the magnets, the value of the exciting current has been reduced until it corresponds only to a small fraction of the total power absorbed by the brake. A further advantage of this useful device is that the brake is good

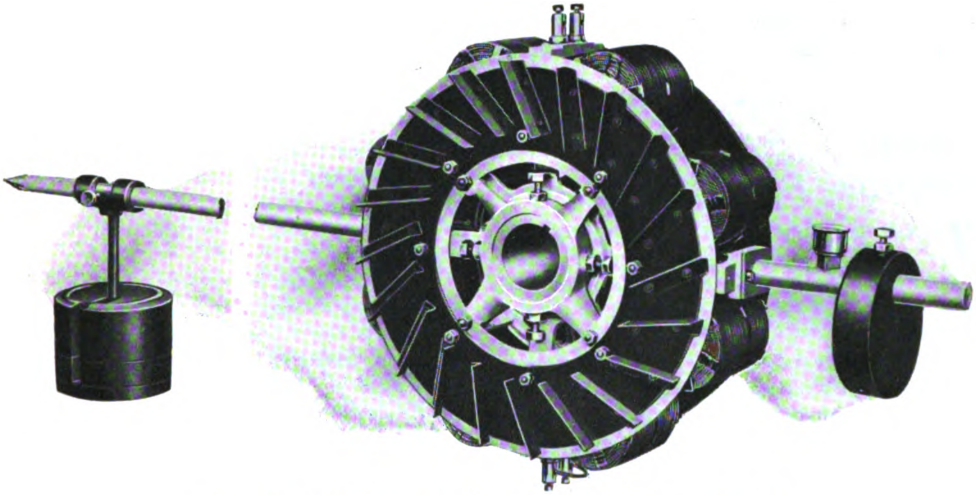


Fig. 1. The Morris & Lister Electric Absorption Dynamometer.

for overloads of 50 per cent. to 100 per cent. for short-time tests at standard speed.

There are a number of interesting details in the design of such brakes.

The copper layer on the iron discs must be of the proper thickness—about 1mm. for standard speeds, and $\frac{3}{4}$mm. for high-speed brakes. As the designers showed in their I. E. E. paper two or three years since, it is just as bad to have the copper too thick as too thin.

Mechanically the brakes are so designed that the revolving discs are secure not only against the considerable retarding force which they have to exert, but against the still larger forces which occur due to the drawing-in action of the pole faces when the brake is excited.

Since the power absorbed by the brake is expended in heating the revolving copper discs, the latter necessarily work hot. But it is important that the heat should not be conducted down the arm of the spider into the framework of the brake. This is provided for by the use of mica at the place where the disc is secured to the spider. This connection is also designed to allow for the expansion of the discs, with increase of temperature, and to ensure that the discs will run true whether hot or cold.

The brake has lately been developed for the testing of high-speed petrol motors. For this purpose it is fitted with ball bearings in place of the ordinary journal, and it is generally found convenient to mount the brake on a shaft, also running in ball bearings, carried by a frame erected on the test bed. The end of this shaft is fitted with a face-plate coupling or dog clutch for connecting to the petrol motor under test. For these high speeds special attention is directed to the balancing of the revolving system.

The eddy current brake is built in four sizes: 3b.h.p., 1500r.p.m.; 6b.h.p., 1200 r.p.m.; 14b.h.p., 1000r.p.m.; 35b.h.p., 750r.p.m, each size being capable of absorbing proportionally more b.h.p. at higher speeds. It is made by Messrs. Morris &

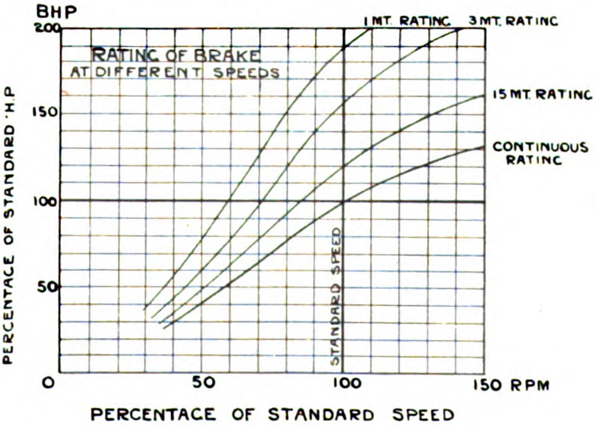


Fig. 2.

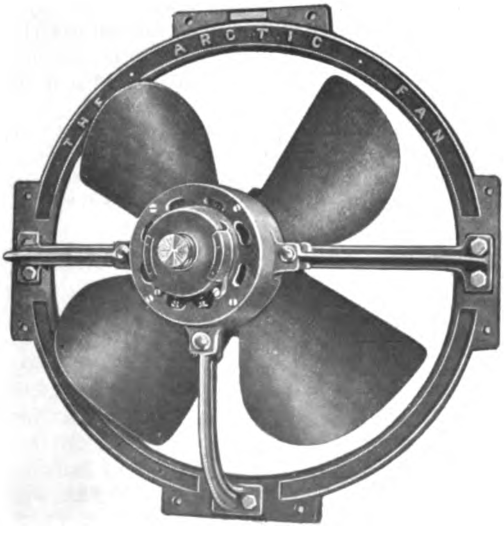
Lister, of Coventry, for whom Messrs. Frampton & Paine, Westminster, are representatives.

"Arctic" Propeller Fans.

THESE fans have been partly redesigned for the 1908 season, and contain many new improvements. The fans are now made for belt driving as well as for the electric drive. The new "propeller" type of blade is said to have a very high efficiency, surpassing that of the old-fashioned box type of blade, in air-moving capacity, by 30 per cent. to 70 per cent., according to size. There is still a prejudice, however, in favour of the box type of blade in certain quarters, and the makers, The Wilson-Wolf Engineering Company, Ltd., Bradford, supply that type if desired.

The motors, in the belt-driven fans, are bolted to the frames of the fans, by three arms of "T" section, which combine great rigidity and strength with the least resistance to the passage of air. The peculiar construction of the fan blades, and the method of fixing to the motors, ensure steadiness of ruuning, freedom from vibration, and silence. It will be found that the "swish" of air, characteristic of ventilating fans, is entirely absent in fans of this design.

The motors are exceedingly compact, the frames being of cast iron of circular pattern. In the 12in. and 15in. sizes the motors are "totally enclosed," and the sizes of 18in. and upwards are usually made "enclosed ventilated," and fitted with hinged doors over the commutators. They can, however, be made "totally enclosed" and dust proof without extra charge. Steam and damp proof motors can be supplied at a slight extra cost.



"ARCTIC" PROPELLER FAN.

The motors are series-wound in all sizes, two-pole up to size 24in., with the poles cast solid with the frame; and four-pole above that size, fitted with cast-steel poles of high permeability.

All sizes have "former"-wound armatures, and all windings undergo treatment by a special process making them absolutely impervious to moisture. Burnt-out armature and field coils are practically unknown. The commutators are made of the best hard drawn copper assembled under hydraulic pressure with best white India mica, and mounted on the socket between shaped micanite rings. The brushes are of carbon, feeding radially, and are easily accessible on raising the hinged covers.

A special feature of the fans is the combined "thrust and journal" ball bearing, fitted at the commutator end, which takes the thrust in either direction, in addition to the journal weight. This bearing runs in grease, and is enclosed in a brass cap, which screws into the nose of the end shield, and contains the grease. The other bearing runs in an ordinary gun-metal bush, and is fitted with a "Stauffer" lubricator. This arrangement does away entirely with the necessity for fitting an arm on the opposite side of the fan when required to feed the air in the opposite direction (or when the fan is fixed to a ceiling with the motor above the blade), thus reducing the cost, and enabling the makers to supply a standard fan for any purpose.

It also enables the fans to run for lengthy periods without attention. There are instances on record where the fans have run continuously night and day in boiler houses and similar positions, exposed to dust and fumes, for periods of six months, entirely without attention and without any visible signs of wear in the bearings. It has not even been found necessary to replenish with grease.

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Drum Pumps.

As will be seen from the small diagram Fig. 1, the Drum pump is of a distinct type. It consists essentially of a revolving piston working in conjunction with a revolving valve or drum, the piston and valve engaging each other as shown. The action of the piston is to sweep the water before it, and it handles the water in one continuous flow without pulsation or interruption. The power is applied to the pump only at the piston shaft, the valve riding loose. This is an important feature making for general reliability and efficiency. It will be seen that whilst this type of pump is good for all ordinary water services, it possesses exceptional advantages for dealing with semi-fluid or dirty and corrosive liquors. The same principle, and indeed the pump itself, can also be used as a blower or gas exhauster.

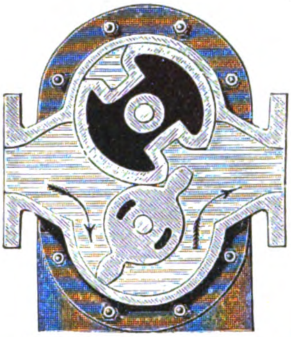

Fig. 1. Section of "Drum" Pump Cylinder.

Some of the particular claims of the makers are that the pump will give equally good results working in either direction; that it will operate over a wide range of speeds; and that mechanically, having no valves nor pulsation in delivery, it is reliable, and wear and tear losses are at a minimum. It is built in sizes ranging from a capacity of 650 gallons per hour up to 24,000 gallons per hour, at 300r.p.m. and 150r.p.m. respectively, and adapted for either belt, turbine, engine, or electric driving. The second illustration shows a typical electrically driven Drum pumping set complete as arranged for a standard type of slow-speed motor. The makers of the pump are the Drum Engineering Company, of Bradford, from whom full details and further particulars can be obtained.

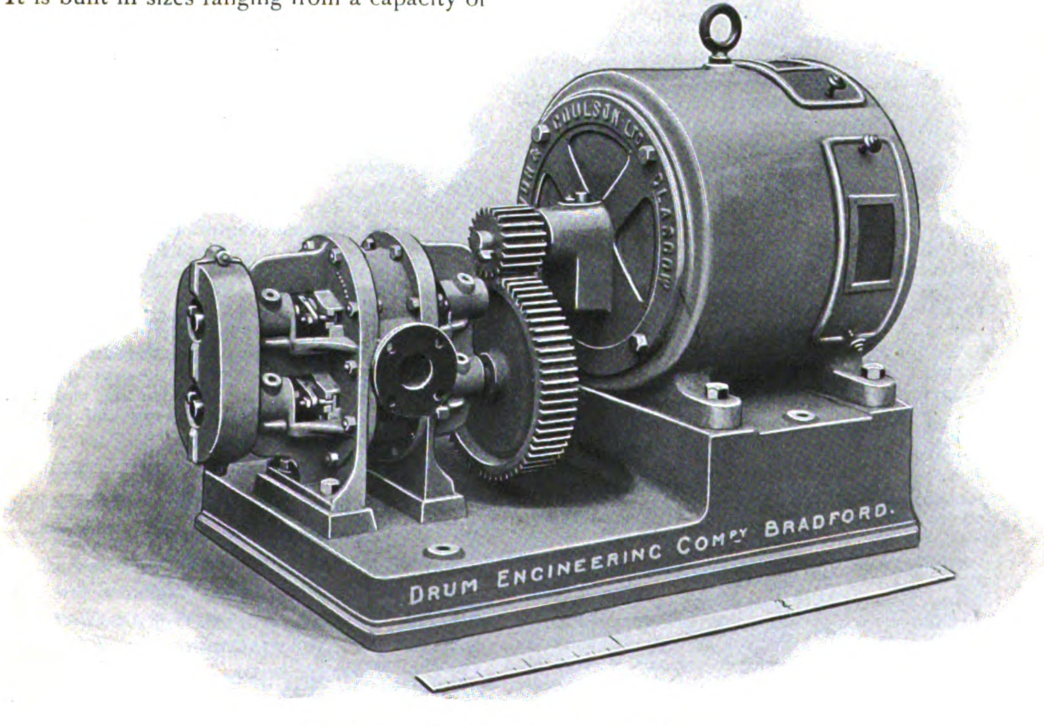

Fig. 2. "Drum" Pump with Electric Motor.

New Catalogues.

Telegraph Apparatus, &c.—Walters Electrical Manufacturing Company, Ltd., London, W. A well-bound and fully illustrated catalogue and price list extending to upwards of 100 pages and including particulars of every class of telegraph instruments, apparatus, linesmen's tools and material.

Weighing Machinery.—Hodgson & Stead, Ltd., Manchester. Catalogue giving illustrations and particulars of a great many types of weighing machines, weighbridges and various styles of scales for different purposes. This catalogue will be found of considerable interest and value by most engineers.

Glass Shades.—Sun Electrical Company, Ltd., London, W.C. Circular No. 161 gives illustrations and prices of a new line of shades recently introduced for use with Osram and Tantalum metallic filament lamps.

Portable Wattmeters.—Union Electric Company, Ltd., London, S.E. List No. 8009 gives illustrated description and prices of a line of portable wattmeters suitable for direct and single-phase alternating current circuits. The list also includes particulars of neutral point resistances so that measurements can be taken on three-phase circuits. These instruments appear to be exceptionally neat in design, and will doubtless meet with much favour amongst central station men and power users generally.

Transformers for Lamps.—Union Electric Company, Ltd. List No. 1402 deals with small transformers having a secondary voltage of 25 volts, and intended particularly for use with low candle power metallic filament lamps.

"Excello" Arc Lamps.—Union Electric Company, Ltd. List No. 5004 gives a very complete description of the well-known "Excello" Arc Lamps, dealing at length with the application of the lamps to various circuits and with the operation and treatment of the lamps. This is a publication which should be in the hands of all who are interested in the question of efficient arc lighting. This Company also send us list No. 1401 which gives particulars of an ingenious type of strain release and arc lamp couplings as used for outdoor pole lighting systems.

Polyphase Motors.—Union Electric Company, Ltd. List No. 1007 deals at length with a very complete line of polyphase induction motors which the Union Electric Company have on the market. The range of machines covers from ¼b.h.p. to 340b.h.p., of speeds from 1500r.p.m. down to 375r.p.m., voltages from 110 to 5000. The several forms of windings and brush-raising and short-circuiting arrangements are given, as also are full particulars of main dimensions of machines and prices.

Osram Lamps.—General Electric Company, Ltd., London, E.C. A well-produced catalogue, No. S 1233, gives full descriptions of the several types of Osram lamps now on the market and hints as to their arrangement on specified circuits. This list shows that it is now possible to use Osram Lamps up to 50c.p. burning in any position. The list also gives particulars of auto-transformers for reducing the supply pressure on ordinary alternating-circuits down to 100 volts or less.

Another catalogue of the General Electric Company, No. G 1231, gives prices and illustrations of a very wide assortment of glass shades as suitable for electric fittings.

Trolley Wire Suspensions.—Consolidated Accessories Company, London, E.C. The pamphlet designated "T.S." reprints a full description from *The Electrical Review* of the Pringles Patent Tangential Suspension for overhead conductors. This system exhibits many noteworthy features and all tramway engineers and others interested in the installation of overhead conductors should procure a copy of this publication.

Main Testing Sets.—Elliott Bros., Lewisham, S.E. Section G of Messrs. Elliott's catalogue gives a full description of the Century portable mains testing set as used for general testing work. This testing set is suitable for making all the measurements ordinarily required in connection with supply mains. It is essentially portable and compact and at the same time combines a high range of readings with great accuracy.

Switches and Accessories.—George Ellison, Birmingham. A well got-up catalogue giving particulars of switches, circuit breakers, fuses, &c.; also of motor starters, of which the alternate-current motor-starter as fitted with no-voltage and overload release devices is worthy of special mention.

Telephone Convenience.—General Electric Company, Ltd. The Phone-Eze telephone bracket is described in catalogue No. K 1234. The bracket is essentially a beam for fixing in either desk or wall, carrying both transmitter and receiver. The bracket can be swung in any direction over a considerable range, and will doubtless be found of very great convenience to the majority of telephone users.

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Trade Notices.

Messrs. Evershed & Vignoles, Ltd., advise us that they have appointed Mr. S. Thomas Pemberton, Council Chambers, 109, Colmore Row, Birmingham, as their agent for the Midland Counties. His headquarters are in Birmingham, and his dristrict embraces Warwick, Worcester, Nottingham, Derby, Leicester, Stafford, and Shropshire.

Mr. John J. Inniss, M.I.Mech.E. (who, by the way, was the first president of the Birmingham and District Electric Club) has been on a business tour through China since last November, and has now opened a branch office in connection with his firm, Messrs. Inniss & Riddle, of Birmingham, at 40, Szechuen Road, Shanghai, where the firm will conduct their Chinese business as consulting electrical and mechanical engineers, machinery and general import merchants.

APPOINTMENT WANTED.

BELGIAN MINING and ELECTRICAL ENGINEER, with good knowledge of English and German, proposes his services as Projecting Engineer of an Electrical firm or for Superintending an Electrical Plant. Moderate terms. Full particulars on application. Address, P.C.R., 49, Poste Restante, Verviers, Belgium.

The
Electrical Magazine.

Vol. IX. No. 6. London. June 15th, 1908.

The World's Electric Progress.

The Mining Exhibition at Olympia.

OLYMPIA will shortly be taken possession of by an army of engineers and workmen bent on installing the mining machinery with which the large main hall is to be entirely filled. A large proportion of this machinery will be shown in motion.

In spite of the exceptional size of the exhibits—many of the firms occupying two or three times the space covered by them at the last Colliery Exhibition—we have no doubt that Mr. H. Greville Montgomery, M.P., will be able by July 11th, the opening day, to have everything in that state of preparedness for which his exhibitions are famous, and in which many others have fallen so lamentably short. In this respect we have at the moment a telling example in the Franco-British Exhibition; but it is to be hoped that the gigantic show at Shepherd's Bush, which is already and quickly living down its unfortunate reputation as being behind time in every way, will be in complete going order by July, since of the large number of pleasure-seekers intending to visit the great International Fair next month many are certain to be interested in the important technical exhibits to be seen at Olympia hard by.

The general public, too, will find that the latter has very much to offer in the way of unique attractions; at the Mining Exhibition much popular interest is sure to be accorded the exhibits showing realistic representations of mining life. The annexe at Olympia will be converted into a huge diamond prospecting camp, with tents, miners washing diamonds, &c., while in the galleries will be shown the active operations of alluvial, underground and hydraulic gold-mining, tin-mining, coal-mining and quarrying of various kinds.

Altogether the Mining Exhibition promises to be the most representative show of its kind ever seen in this country, and we can but trust that it will prove as profitable to its promoter as it is certain to be to the exhibitors.

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Electricity in Mining.

The forthcoming mining exhibition is certain to prove a great centre of attraction for electrical men, and will play no small part in the further bringing together, in a business sense, of the mining and electrical industries. It is intended that THE ELECTRICAL MAGAZINE for August shall take the form of a special number dealing comprehensively with the most modern developments of electrical engineering as applied to mining practice. Whilst the lessons of the Mining Exhibition will be duly recorded, we are arranging to publish at the same time a series of original articles by practical mining men and leading engineers engaged in the equipment and handling of electrical mining schemes. Without going into further detail at this writing it will be sufficient to announce that our Mining Number is to be as complete as possible in covering the entire field of mineral-getting by the latest and most approved methods and plant. The publication of this number, following the run of the Mining Exhibition, will be opportune, and we feel confident that readers will appreciate the result and that the manufacturers supporting us in this will secure exceptionally good returns.

We invite readers having experience of electrical mining practice to submit articles for our consideration, and also request that electrical and general machinery manufacturers will send us particulars of their newest specialities as intended for mining service.

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The Electrical Exhibition.

AT this comparatively early stage the interest evinced by electrical and general engineering firms in the forthcoming Manchester Exhibition is exceptionally keen. Already a large proportion of the stands have been secured, and particulars are available of many of the intended exhibits. Striking evidence of the capable organisation behind the scheme is the effort which has been successfully made to bring the workaday interest of applied electricity thoroughly into prominence; thus we find that machine-tool makers, textile machinery manufacturers, &c., have combined with builders of electric motors to put before visitors their respective machines engaged in actual service, and vastly interesting it will be to the people of the neighbourhood to watch the skilled mechanic, the cotton spinner and the Lancashire lass as weaver, turning out finished product on the most up-to-date machines and in the manner adopted in the very latest style of tool shop or cotton factory.

A considerable part of the Exhibition will be taken up with the "domestic electricity" section, where every type of household fitting in conjunction with the latest forms of electric lamps and lighting systems will be shown. In this connection a popular feature is sure to be the several exhibits of electric cooking and heating appliances, which will as far as possible be seen in actual service, and about which practised experts will lecture and give ample demonstration at frequent intervals.

Every possible effort is to be made towards showing in a practical manner the beneficial effects, in the industrial and social senses, which arise from a full and accurate understanding by the public of the uses of electricity. It is confidently expected therefore that the many Corporations of Lancashire and Yorkshire manufacturing towns who are taking an active interest in the promotion of the Exhibition will quickly earn their reward in sending up the central station loads and seeing the working conditions and home life of the citizens placed on a higher and more economical basis.

The large new building which is being provided for the purpose of the exhibition on a convenient central site presented by the Manchester City Corporation is quickly approaching completion, and exhibiting firms will thus be afforded ample time for the erection of exhibits and ensuring everything being finished and in thorough running order by the opening date.

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A New Industry.

THE article by Mr. F. S. Spiers in another part of this issue will appeal with particular force to those who are of a speculative turn of mind, and on the *qui vive* for a new industry—one in which pioneer work is demanded, and into which the profit-absorbing competition of the standard manufacturing business has not entered, but where there is the greatest possibility of a rich harvest falling to the man of enterprise. That there is very widespread interest in the utilization of the atmospheric elements for the manufacture of nitrogen compounds is evident by the large number of enquiries we have received from readers in all parts of the world. In the article under notice, the author has covered the entire ground of the work so far done in the production of nitrogenous manures by the electrolysis of air. The chemical actions involved and the mechanical ingenuity shown by the several original investigators as described by the author will be found of great value by the many who will doubtless follow up this work now that the processes have in some cases revealed a decided commercial worth.

It would indeed seem that the future work of development will be mainly towards the perfecting of industrial plants—for, as always, the question of pounds, shillings and pence is of paramount importance. Considering that the raw materials, the atmosphere, are always and everywhere to hand, of no cost, and illimitable, the controlling factor in the economy of production is merely the availability and cost of electric power. Mr. Spiers deals conclusively with the efficiency of the electrolytic conversion, and from this, supported by figures obtaining in practice, deduces the cost of the finished product in terms of the price of the kilowatt-hour. At the large plant put down in Svaelgfos, Norway, saltpetre can be produced for a total inclusive cost of £4 per ton, the price of Chili saltpetre of equivalent nitrogenous value being over £8 per ton. In this case the price of the electric supply is remarkably low, being only about 25s. per horse-power annum, but the figures quoted for the artificial and natural products are so far apart as to leave no room for doubt that the former will eventually displace the latter. Speaking generally, it would appear that the artificial product of atmospheric electrolysis can compete with the supply drawn from the natural deposits of Chili saltpetre when electric energy can be obtained at less than one-tenth of a penny per unit. Such prices for electricity are easily obtainable where the natural power of waterfalls is available; and, more important to us, there are with this new industry great possibilities arising for the profitable utilization of the large waste or bye-product heat supplies of the large industrial plants of this country. In the last two numbers of THE ELECTRICAL MAGAZINE full references were made to the enormous powers to be saved by the proper handling of the exhaust-steam, blast-furnace and coke-oven gases of steel and iron making plants; it would seem that the facts given by Mr. Spiers merit the particularly close attention of iron and steel works and colliery proprietors and all such as have bye-product or natural sources of power at hand.

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"Liconite."

At the Charlton Works of Messrs. Johnson & Phillips, representatives of the technical press were recently afforded the opportunity of judging as to the merits of a new compound for cable insulation. The new material, known as "Liconite," is an invention of Mr. Ali Cohen, of Singapore, who having had much to do with the collecting and exporting of gutta-percha, was led to believe that it would be possible to blend certain hydro-carbons and produce a material which should possess exceptionally good value as a flexible insulator. Certainly the cables and specimens of "Liconite" shown indicate that the substance is one which can readily be worked with, either as a viscous fluid or in the form of solid elastic sheets or tapes. In general appearance a sheet of "Liconite" is black and bituminous, but it exhibits a dense and highly elastic nature, and, indeed, would seem to be an entirely new material capable of forming an effective substitute either for bitumen or rubber as an insulator and possibly for many other purposes.

Having adopted a policy, Mr. Cohen adhered to it with a pertinacity worthy of commendation, and after years of research returned to Europe, where he has since been experimenting on an extensive scale. These larger experiments have been possible owing to the valuable financial and commercial assistance given to Mr. Cohen by Messrs. A. Hendrichs & Co., of Amsterdam, the owners of the "Liconite" Patents covering

Europe and America, and they are financially responsible for the present highly interesting and scientific position of the "Liconite" manufactures. On the occasion of our visit to the Charlton Works there were various lengths of "Liconite" cable ready for testing, these lengths having been manufactured by means of the experimental plant and machinery recently erected at Charlton.

One sample consisted of a 220yd. length of three-phase cable for a working pressure of 25,000 volts between each core capable of carrying 65amp., that is, of transmitting, say, 500kw. The core was of standard aluminium, lined with a thin coating of lead for the purpose of reducing electric stress. Notwithstanding this, it showed itself extremely light and flexible, and therefore easily handled and installed; it is suitable for underground or surface work, and it is claimed by the owners that this cable laid underground would involve less expenditure of capital for high tension transmission than an overhead line, while at the same time it is more permanent and durable and would cost less for maintenance.

Another cable consisted of 220yds. of .25 square inch of stranded copper insulated with paper treated with "Liconite." This cable had no lead covering whatever, the insulation being merely mechanically protected by Hessian tape. It was shown that this cable after being submerged for long periods in water withstood the highest flash tests (70,000 volts). It was further shown that it maintained this high insulation value even after being wholly submerged in water with the ends of the core bare and unprotected.

Further details of these tests are given on page 425 of this number, and from the results there given it would appear that "Liconite" is a material to be watched by cable-makers and power engineers as offering great possibilities.

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The Franco-British Exhibition.

The enormous interest which the Franco-British Exhibition offers to electrical men, coupled with the incompleteness of the machinery section, has led us to postpone until our forthcoming number any particular references to the electrical features in detail. Happily the actual equipment of the Exhibition grounds for electric lighting and power services has from the beginning been in a very forward state, and as one would naturally expect, with very few exceptions, the entire lighting of the Exhibition grounds and buildings is effected by electricity. The power supply for the moving exhibits is also mainly electric. An idea of the scope of this supply work is gathered from the fact that the installation has been planned for a maximum load of 3000kw., the whole of which comes under the control of public supply authorities in the neighbourhood.

So far as electrical exhibits are concerned these are likely to prove more extensive than was a short while ago thought probable. Many leading firms withheld their support in this direction until the Exhibition was practically open, and this has had a good deal to do with the backwardness of the engineering section. The largest as well as the smallest grades of electrical manufacture appear among the exhibits in the vast Machinery Hall. Thus, for instance, we have a 1500kw. Parsons turbo-generator and a 750kw. Westinghouse gas-driven generator on exhibition and incidentally serving to augment the electric supply of the Exhibition. Then, on the other hand, all the new types of electric glow lamps are exhibited; one of the earliest stands to be completed was that of The Linolite Company, who show a specially large section of their "Tubolite" fitting as recently evolved for special lighting in theatres and places where a stronger light than usual is required.

As said, we can at present but briefly touch upon this matter, but propose to devote the July number of The Electrical Magazine to a series of descriptive articles which shall give the due and proper prominence to the electrical interest of an exhibition which will undoubtedly for many years to come be without parallel.

THE ELECTRIC FIXATION OF ATMOSPHERIC NITROGEN.

F. S. SPIERS, B.Sc., A.M.I.E.E.

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IN 1898 Sir William Crookes, in his now famous presidential address to the British Association, warned the civilised world that the natural stores of nitrates—Chili saltpetre—on which it depends for the regular supply of its daily bread, were likely to be exhausted before the middle of the twentieth century, and that unless some practical method was perfected for the manufacture of artificial manures starvation was likely to be the sorry end of the bread-eating inhabitants of this planet. In the ten years that have elapsed since 1898 the knowledge, skill, and perseverance of a handful of experimenters have succeeded, with the aid of electricity, not only in proving the possibility of making nitrates from the air, that inexhaustible store of precious raw material containing some four trillions of tons of nitrogen, but actually in establishing an entirely new nitrate industry. The result is that atmospheric nitrogen fixed electrically, or indirectly with the aid of electricity, in the form of calcium cyanamide, calcium nitrate, or nitric acid, is now a marketable commodity, only waiting for the inevitable rise in prices as supplies visibly diminish, to compete seriously in the open market with Chili saltpetre. As a matter of fact the artificial nitrates, in some districts where the conditions for the cheap production of electric power are favourable, and freight rates on the mineral saltpetre are heavy, are already selling in direct competition with the natural nitrogenous manures. In fact, thanks to the electrical (or rather the electro-chemical) engineer, the nitrate problem is now solved, and it will be quite possible to supply the farmer, as soon as ever he asks for it, with manure enough to grow wheat sufficient to feed untold generations of mankind.

Historical.

Like all inventions and discoveries in science, the way to fix nitrogen efficiently and economically took many years to discover, and was the work of many minds. It was Priestley, and afterwards Cavendish, towards the end of the eighteenth century, who first recorded the oxidation of nitrogen by electric sparking through air, but the master-discovery did not begin to bear practical fruit—at least from the present point of view—for over 100 years. In 1892 Sir William Crookes showed that high-tension arcs were most suitable for causing direct combination between oxygen and nitrogen, and in 1897 Lord Rayleigh, while engaged on the experiments that led to the discovery of argon, followed up Crookes' work by really proving the economic possibility of oxidising nitrogen by means of the electric arc. Lord Rayleigh worked with a 2000-volt arc in a closed glass vessel of 50 litres capacity, and his vessel contained not pure air, but a mixture consisting of eleven parts of oxygen to nine parts of air. A jet of caustic soda absorbed the oxides of nitrogen formed, and kept the globe cool. With this simple apparatus, using energy at the rate of about one horse power, it was possible to obtain fifty grams of nitric acid per Board of Trade unit absorbed by the arc—a very remarkable result for so early a stage in the development of the process.

Lord Rayleigh's experiments were followed up by McDougall and Howles in Manchester, who, using specially-shaped vessels in which the air could be forced through the arcs at a very great speed, obtained a yield of

67 grams of nitric acid per Board of Trade unit, using Lord Rayleigh's mixture of oxygen and air, and 34 grams per unit using ordinary air.

Side by side with the arc furnace method of fixing nitrogen, another important method has been steadily developing, namely, the manufacture of calcium cyanamide or lime nitrogen ($CaCN_2$), but as this is chiefly of chemical and only indirectly of electrical interest, brief mention of it here will suffice. The method is the discovery of Frank and Caro of Berlin, who found that both barium carbide and calcium carbide at a red heat absorb nitrogen, forming compounds which decompose in the soil with the liberation of ammonia, and which are thus directly available as fertilising agents. Unfortunately fixation by means of the cheap and abundant calcium carbide is less complete than when the more expensive barium carbide is used, but there is in all probability a future for calcium cyanamide, which is being manufactured on a commercial scale by the Cyanidgesellschaft of Berlin, while a 3000h.p. plant is about to be put into operation in Italy, and the large Odda (Norway) works of the North-Western Cyanamide Company, who hold the English rights, are now approaching completion. It is worth recording that in these works combination between the carbide and the nitrogen will, for the first time, be brought about in electric core-resistance furnaces. Although it is somewhat early to express a definite opinion, on the whole it cannot be said that the prospects of calcium cyanamide manufacture are at present quite so promising as is the arc method of burning atmospheric nitrogen, in view of the fact that the raw material in the latter case is free in unlimited quantities.

Best Conditions for the Electric Oxidation of Nitrogen.

The work of McDougall and Howles ends the first or laboratory stage of the process of fixing nitrogen in the electric arc. It had been shown that the process was practically possible; it now remained to be discovered whether it was economically possible from the commercial point of view. Here the question of efficiency of the process immediately arises, and it will be well to devote a short space to the consideration of this aspect of the subject as well as to the cognate question as to the best working conditions under which high efficiencies are possible. Now it can be shown that at the temperature of a properly-burning high-tension arc, say about 4200deg. C., the energy required to effect the combination of the nitrogen and oxygen of the air is equivalent to a yield of 134 grams of nitric acid per kilowatt-hour of electrical energy—about four times that obtained by McDougall and Howles. At a lower temperature the theoretical yield is less; at 3200deg. C. it is only 93.5 grams per kilowatt-hour. It should be here mentioned that in the opinion of most chemists the action of the electric arc in oxidising nitrogen is not in any way electrical or electro-chemical, but is merely a thermal effect. The theoretical yield can, of course, only take place when there is no re-conversion into their constituents, nitrogen and oxygen, of the oxides of nitrogen as produced. To prevent this dissociation, it is necessary that the products of combustion should be immediately removed from the high temperature of the arc and cooled as quickly as possible, and this is best effected by using long, thin arcs —very small compared with the volume of air under treatment—and thus heating the air for a very short period. In this way radiation is reduced to a minimum, and the maximum rate of cooling of the nitrates formed is obtained. Once these conditions were well understood from the work of the laboratory experiments, and notably from the valuable work carried out in Geneva (1893-1896) by Naville and Guye, as well as from the researches of McDougall and Howles, the problem on this side resolved itself into the production of suitable high-tension electric arcs. The type of arcs most suitable are those in which the low temperature zones (900deg. C. to 1400deg. C.) are as far as possible minimised, since in the high-temperature zone (4200deg. C.) alone, the hottest of the three zones found in the high-tension arc, is it probable that oxidation of nitrogen occurs. Several methods have been devised for producing these arcs, and of these three have been tried on a practical scale—those of Bradley and Lovejoy, Kowalski and Moscicki, and Birkeland and Eyde.

The Bradley and Lovejoy Process.

Bradley and Lovejoy produced their numerous, thin, long-drawn high-tension arcs by mechanical means. The apparatus consisted of two concentric cylinders from the inside of the outer and the outside of the inner of which projected a large number of platinum points. The drums were connected up to a 10,000-volt direct-current generator, and as they were rotated a large number —as many as 6900 per second—of small long arcs were formed which produced oxides of nitrogen from the air driven between the cylinders. About 250 to 300 arcs were burning at one time, and as the total current was 1amp., each arc consumed about 3×10^{-3} amp. The process was worked at Niagara by the Atmospheric Products Company, but although a very fair yield was obtained, equivalent to 88.3 grains of nitric acid per kilowatt-hour, the practical difficulties in dealing on a commercial scale with so large a number of small arcs led to the process being abandoned.

Kowalski and Moscicki Process.

The essential feature of this process was originally the use of very high frequency alternating-current arcs, a method attended by great practical difficulties. Tensions as high as 50,000 volts and alternations as frequent as 6000 to 10,000 periods per second, the arcs being used in conjunction with a special arrangement of condensers and induction coils, were employed in the 100h.p. experimental plant at Vevey in 1903, but, influenced possibly by the Birkeland-Eyde process, the inventors are now experimenting with low-tension (1500 volts) direct-current arcs produced between two vertical concentric copper electrodes and rotated by spinning magnetic lines of force. The excellent yield of 60 grams of nitric acid per kilowatt-hour has been obtained in the 36h.p. experimental furnace, but the process has not up to the present reached the industrial stage.

The Birkeland-Eyde Process.

The feature of this process is the electro-magnetic repulsion which is made use of for drawing out the elements of arc flames. The 5000-volt alternating-current arc (frequency 50 periods per second) which burns between water-cooled tubular electrodes of copper (Fig. 1)—about ½in. in diameter and ⅜in. apart—is placed transversely between the poles of a powerful direct-current electro-magnet. The arc at starting moves across the field with enormous velocity, and thus its length, and therefore its resistance, are so much increased that the heightened tension causes a new arc to spring across the points of the electrodes and the long outer arc is extinguished. As the positive and negative arcs produced on the successive reversals of the current are repulsed in opposite directions, the net result is the formation of a complete circular disc of flame over a yard in diameter and about 1½in. thick, which under the proper electrical conditions fairly closely approximates to the ideal arc referred to before, in which the high-temperature zone predominates, and in which there are no gradual temperature-falls to cause dissociation of the nitrogen oxides formed. The arc when properly regulated by a suitable inductive resistance is quite stable, and its power factor is remarkably high. The disc flame, which is shown diagrammatically in Figs. 2 and 3, and of which a photograph is shown in Fig. 4, is enclosed in a specially constructed furnace, and air is driven rapidly through it by means of blowers (see Fig. 5). In the present 500-kilowatt furnaces air is driven through at the rate of 75,000 litres per minute, and of this one-quarter is directly acted upon by the arcs. The Birkeland-Eyde is undoubtedly the most successful

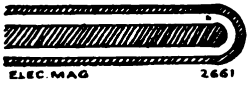

FIG. 1.

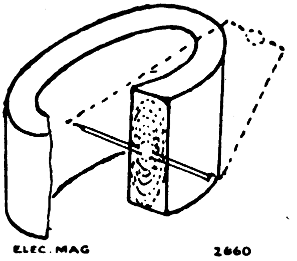

FIG. 2.

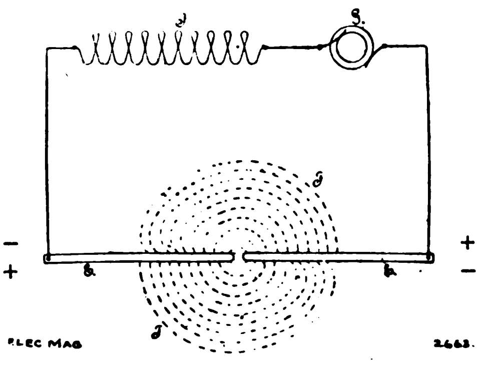

FIG. 3.

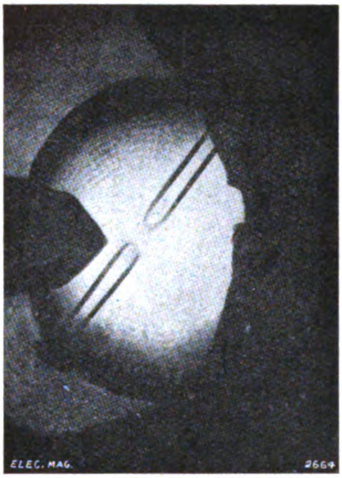

FIG. 4.

of all the electric arc methods that have been devised for the direct fixation of atmospheric nitrogen. At Notodden, in Norway, the process has been subjected to very severe and exhaustive tests at the hands of a distinguished international commission, and in the three 500-kilowatt furnaces that have there been working an average yield of 65 grams of nitric acid per kilowatt-hour has been constantly obtained, while the best results actually reach the remarkable figure of 106 grams per kilowatt-hour, being nearly 80 per cent. of what is theoretically obtainable, assuming the temperature of the arc to be 4200deg. C., and an even greater efficiency if, as Prof. Birkeland supposes, the average temperature of his arc flame is only 3200deg. C. The chief sources of energy losses in this process are in the electrodes, the cooling of which accounts for $7\frac{1}{2}$ per cent. of the energy supplied to the arcs. The electromagnets absorb only $\frac{1}{2}$ per cent., and the air blowers and other accessories account for a further energy consumption of 4 to 5 per cent. in all.

The oxidised nitrogen as it issues from the arc, whether in the Birkeland-Eyde or any other arc process, consists of nitric oxide (NO) much diluted of course by unacted-upon air, and this has to be converted into nitric acid or some alkali nitrate before it can be placed on the market or used by the farmer. At the Notodden works, the air after passing through the furnaces contains from 1 to 2 per cent. of nitric oxide. As it cools, first in a steam boiler (from 700deg. C. to 200deg. C.), and finally in oxidation chambers, the nitric oxide becomes further oxidised to nitrogen peroxide (NO_2). This is dissolved in water in four stone absorption towers filled with quartz over which water trickles, and it is here that solutions of nitric acid are formed in strengths varying from 50 to 5 per cent. in the successive towers. In a fifth tower milk of lime absorbs the remaining nitric gases. The solution from the system of towers is eventually led to granite tanks, where it reacts with limestone to form calcium nitrate, and in this state, after concentration, it is placed on the market as a manure in every way equal, and for some soils superior, to Chili saltpetre.

A Large Norwegian Plant.

A 27,000e.h.p. plant is now in course of erection at Notodden which will take its power from the Norwegian Hydro-electric Company's generating station on the Svaelgfos Waterfall, three miles away. The capacity of the fall is 22,000 gallons per second, with a head of 154ft., and it operates four turbines each of 10,000h.p. to 12,000h.p. The hydro-electric plant presents many features of considerable engineering interest. The furnaces themselves will have a capacity of 750kw. to 850kw. each, and it is anticipated that they will yield, at the very least, the equivalent of 13,000 tons of nitric acid per annum, and probably half as much again.

As regards costs the Notodden works are particularly favoured, since they are at present able to buy electric energy at the very low rate of 25s. per e.h.p.-year (0.034d. per b.t.u.), and the cost will be even less

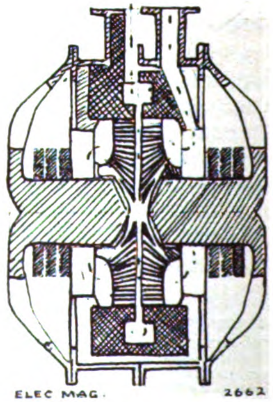

FIG. 5.

from the new power station at Svaelgfos. At this figure the *inclusive* cost of production of a 13.2 per cent. nitrate is £4 per ton, while the market value of Chili saltpetre of equivalent nitrogen content is at present over £8 per ton.

Other Processes.

A large number of inventors, both in Europe and in America, are now working on the nitrate problem, and although none of the newer processes or modifications have yet reached the industrial stage, many of them possess features of novel interest. One of the most promising of these is that of the great German firm, Badische Analin und Soda Fabrik. The original feature of this process is the single long arc, which burns to a length up to 10ft. in a vertical iron tube (shown in Fig. 6) between the wall of the tube itself and one or more insulated electrodes. Air, with a whirling motion imparted to it, is sent along the tube, and this carries the arc right along to a second electrode at the further end of the tube. A comparatively low voltage (a few thousand volts) is employed, and excellent yields (74 grams of nitric acid per kilowatt-hour) are said in the patents to have been obtained. No detailed figures have as yet been published, but the process is no doubt being tested on a commercial scale.

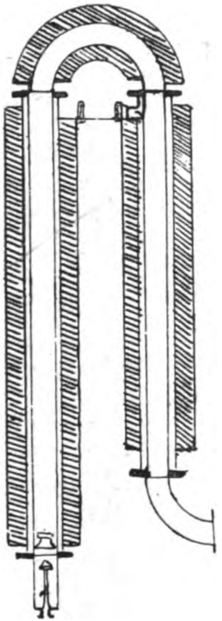

FIG. 6.

Another interesting method is that of Pauling. In this electrodes, straight or curved, inclined to one another at an angle, funnel-wise, are used. An air blast carries the arc mechanically from the nozzle, or close ends, outwards towards the spread ends of the electrodes, lengthening, and finally extinguishing, the arcs, which thus break and form again in regular succession. This process is being worked in Austria by the Saltpeter-säure Industrie Gesellschaft.

In Russia the Gerbov and Mitkievitch arc furnace is about to be worked on a technical scale. In this the current of air draws the arc (600-1500 volts) into a worm, in whose mouth is formed a bunch of fire through which all the air has to pass, the products being immediately cooled in the further part of the worm. In a small 14kw. experimental furnace a yield of 56 grams of nitric acid per kilowatt-hour has been obtained.

The simple and effective furnace of the Geneva chemists, Naville and Guye, whose pioneering experimental work already referred to has been of great value, should not be allowed to pass unnoticed. These inventors use a rotating disc forming one electrode, and a metal tube, through which the air is driven to impinge against the rotating disc, for the second electrode. Here again the current of air itself causes the necessary spreading of the arc, and fair yields—about 46 grams of nitric acid per kilowatt-hour—have been obtained in this very cheap and simple apparatus. Messrs. Naville and Guye (Société des Etudes Electro-chemiques) are continuing their important experimental work, studying in particular the later, purely chemical stages of the fixation processes, the conversion of the oxides of nitrogen to a marketable commodity, whether concentrated nitric acid or alkali nitrates for manures.

The Future Prospects of the Electric Fixation of Nitrogen in England.

That the artificial fixation of nitrogen is one of the industries of the future the circumstances of the case leave little room for doubt. As, moreover, whether the nitrification of calcium or other carbides,* or that of the oxygen of the air, finally survives as the best of known methods, electric power must always remain an essential factor in the process; the problem, like all electro-chemical industrial problems, ultimately resolves itself into a question of cheap and abundant sources of energy. Does this mean that countries like Norway and Italy—and especially Norway, whose waterfalls are so often in close proximity to fiords which form perfect harbours—will become the centres of the new industry, while England must for ever remain content to import the food of her soil even as she, unhappily, has to import the food of her people? By no means, because the considerable reserves of available surplus power from blast furnaces alone, that will no doubt one day be utilised in gas engines, are, in the case of England, sufficient to make enough nitrate to feed our whole population with home-grown wheat, and the surplus power from this one source in the whole of Europe could, even with present appliances, make as much nitrate as is now imported from Chili. But there are even more fascinating possibilities in another direction. When coal is treated in modern gas-producers, the greater part of its nitrogen may be recovered as ammonium sulphate, and with the increasing use of large power gas plants the output of this valuable by-product is likely to be very greatly enhanced in the future. Now, if this ammonium-sulphate be utilised in combination with the nitric acid directly formed in nitrogen-fixing arc furnaces, we have, in the resulting ammonium nitrate, the richest and best nitrogenous fertiliser that is known to us. As our coalfields become—as they are in all probability bound to become—more and more the direct centres of power production, the conditions for the economical manufacture of the two constituents of ammonium nitrate, the one in the electric furnace, the other in the gas producer, will likewise become more and more favourable, and it is not unreasonable to hope that long before Chili is unable to send us natural saltpetre, we shall ourselves be making artificially all the nitrates required by our chemical and agricultural industries, using only the coal beneath and the air above our native soil.

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* It has been suggested that aluminium carbide, which likewise unites directly with nitrogen at a high temperature, might be advantageously substituted for calcium carbide. As an impure carbide can be made by heating clay and carbon in the electric furnace, the suggestion seems worthy of serious consideration.

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Soldering Aluminium.

The great difficulty in uniting two pieces of aluminium is due to the fact that at the place of soldering an extremely thin film of alumina is formed which resists the union of the metal with the solder. The use of a solder gives the best results, the autogenous or solderless process not being so reliable. Some 40 different solders are known. Many authorities recommend that the article be first tinned with an alloy of one part aluminium to five parts tin, and some advocate that the same alloy be then used as a solder. Among the solders that are most highly recommended are the following alloys:

Five parts zinc, 2 parts tin, 1 part lead.

Nine parts zinc, 100 parts tin, 165 parts lead.

Forty-six parts zinc, 2 parts tin, 52 parts copper.

Ten parts zinc, 100 parts tin, 20 parts silver, 1 to 6 parts aluminium.

Seventy parts aluminium, 20 parts tin, 10 parts copper or silver.

Thirty parts aluminium, 20 parts copper, 50 parts zinc.

Twelve parts aluminium, 8 parts copper, 80 parts zinc.

Six parts aluminium, 4 parts copper, 90 parts zinc.

Five parts zinc, 95 parts tin.

With the last five the surfaces should be first tinned. The use of a good flux, such as borax, is generally desirable.—*Western Electrician.*

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Effect of Artificial Light on Vegetation.

A French scientist, Camille Flammarion, has published the results of experiments he has been conducting for the last two years to discover the effect of various lights on the growth of vegetation. The tests were made with a large number of various plants which were subjected to red, green, blue and white light, the conditions otherwise being similar.

Under the effects of red light it was found that certain vegetables, such as lettuce, grew fifteen times as fast as under blue light. On the other hand, the experiments proved that blue light has remarkable preservative powers on growing vegetation; thus it is recorded that an oak tree planted two years ago has kept its first leaves, which are now as fresh and vigorous as when they first appeared. In the same way ripe fruit, it is declared, can be kept fresh under a blue screen for twenty days without decay. The strawberry plant can be retarded for a similar period and then allowed to fructify. The experiments are expected to have a wide application to market gardening.

THE EQUIPMENT OF THE OTTAWA MINT.*

A. H. W. CLEAVE.

THE mechanical equipment of this branch of the Royal Mint was completed by the end of October last—the time occupied in the manufacture and installation of the necessary machinery having been just ten months.

Many machines in the coining department have been designed specially for the Ottawa Mint, and in these new devices have been adopted which are not to be found in other similar institutions. In addition to the machinery in that department, where the actual minting of money takes place, the following plants have also been installed:

(1) The electrical plant, for power distribution, for lighting, &c.

(2) The oil fuel plant, for storing and distributing the oil-fuel used throughout the various departments for the melting, annealing, and cupel furnaces, together with the fans and blowers for the same.

(3) The die-making plant, for sinking, turning, annealing, and hardening the dies used for coinage purposes.

(4) The plant for the boiler house and the machine, smith's and carpenter's shops, in which all running repairs are effected and small tools made.

(5) The plant for the assay department, where all the precious metals received into and issued from the Mint are analysed; and in which experimental research work will be conducted.

Electrical Equipment.

The electricity used for power and lighting is supplied in the form of two-phase, alternating current, and enters the building at a potential of 2140 volts. It then passes through the transformers, of which there are three for power and three for lighting. In each case, one is a spare which can be put into circuit, on either phase, as required. The transformers for the power supply operate the motor of a motor-generator set. They are single-phase, step-down, oil-insulated, self-cooled, for a circuit of 60 periods. The primaries are wound for a potential of 2140 volts, and the secondaries for 500 volts. Their normal full-load rating is 100kw. each.

The transformers for the electric lighting system are similar to the transformers for power, but the secondaries are wound for a potential of 107-214 volts; while their normal full-load rating is 15kw. The primaries and secondaries of each transformer are provided with binding posts, so that any one of them may be connected or disconnected without soldering to leads, or cutting wires.

The motor-generator set for transforming the current to operate the motors throughout the Mint consists of an alternating-current motor and continuous-current generator. The motor is of the two-phase, alternating-current, induction type, operating from the transformers at a potential of 500 volts, its normal full-load rating being 225h.p., at a speed of about 800r.p.m. The generator is multi-polar, compound-wound, continuous-current, operating at a potential of 225 volts, its normal full-load rating being 150kw. The motor and generator are on one bed plate, and the set is supplied with suitable auto starter for the motor and field rheostat for the generator.

There are thirty-two compound-wound continuous-current motors in use, ranging in power from 1½h.p. to 30h.p., all operated at a potential of 220 volts. The wiring for the motors is of the parallel two-wire system, the wires being carried in steel conduits.

The wiring for the lighting is of the interior conduit system, all the main circuits being of three wires, and the branch circuits of two wires. There are 415 16c.p. 102-volt incandescent lamps, and 17 arc lamps. The latter are of the enclosed type for multiple circuits, adjusted for 7 amperes and 107 volts, alternating current. The buildings are wired for electric clocks, bells, and telephones, which are in use throughout the Mint.

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* Abstract of paper read before the Canadian Society of Civil Engineers.

Oil-Fuel Equipment.

The fuel used for melting and annealing purposes and for the cupel furnaces in the assay department is crude oil, its specific gravity being .850. The plant for storing, distributing and burning this fuel consists of four storage tanks (each of 2000 gallons capacity), two rotary pumps for distributing the oil throughout the buildings, three pressure blowers, four melting furnaces for crucibles holding 90lb. each, one strip annealing furnace, one blank annealing and one die-hardening furnace, and three cupel furnaces and two small melting furnaces for the assay department. In the melting and cupel furnaces an air blast is used in conjunction with the oil; while in the annealing furnaces and die-hardening furnace dry steam is used at a pressure of 60lb. per square inch. The oil pumps are so arranged that the fuel is delivered to the furnaces at constant pressure. All oil pumped but not used is returned through a spring-loaded valve to the storage tanks.

The tanks are supported on concrete bearers, one at either end, and one at the centre of each tank—so that the air may circulate freely around them. The piping for these tanks is so arranged that each one may be filled or emptied separately. Each tank is also fitted with a return pipe from the pumps, and a vent pipe through which all fumes rising from the oil are led to the roof of the building. The air for the blast used in the melting furnaces is drawn from the tank room, so that the air round the tanks is constantly changed.

This fuel is found to be very economical, and excellent results have been obtained from all the furnaces. The heat can be regulated without difficulty, and, in the melting furnaces, either nickel or aluminium may readily be melted.

Die-Making Plant.

The machinery in this department consists of a die-sinking press, two die-turning lathes, and a die-hardening furnace. The press and lathes are driven by a motor through an overhead shaft. In the die press the blow is given by a heavy flywheel, 5ft. in diameter, which is keyed to a triple screw of 6in. diameter. The flywheel is actuated by two rapidly revolving discs which can be brought into contact with its leather-covered rim. One friction disc raises, and the other depresses the screw. The operator works the press by depressing a stirrup rod with his right foot. This action brings one of the friction discs into contact with the rim of the flywheel, and thus the required blow is given to the die. On the operator withdrawing his foot, a balance weight raises the stirrup, the other friction disc comes into operation, and the screw is raised. After the blow has been delivered the height to which the screw shall rise is regulated by a brake adjustment, and having reached that height it remains there until the stirrup is again depressed. In this press a blow may be given varying from a few pounds to about forty tons.

Each coinage die requires three blows from the punch before the impression received is sufficiently sharp in all its details. After each of the first two blows the die is annealed in the die furnace. After the third blow it is turned to the correct size, and then hardened and tempered, after which it is ready for use in the coining press. It is usual for a pair of dies to strike about 80,000 pieces before they are unfitted for further use.

Repair Shops, &c.

In the machine shop the following tools have been installed:

One 14in. by 72in. Norton roll grinding machine.

One Brown & Sharpe No. 13 universal grinding machine.

One Brown & Sharpe No. 2 milling machine.

One Bertram planing machine.

One Barnes 21in. drilling machine.

One sensitive drill.

One 16in. gap lathe.

One 14in. Pratt and Whitney lathe.

One shaping machine.

One polishing spindle.

In addition to the above, fitters' benches, grindstone, power hacksaw, &c., have been installed.

The roll grinder and the planer are driven by their own motors, while the other machines are grouped.

An elevator is situated in one corner of the shop, communicating with the smith's shop, which is in the basement next to the boiler room.

The smith's shop contains a Buffalo down-draft forge, a Fairbanks 100lb. power hammer, shearing machine, &c.

The boiler room is equipped with two marine-type multitubular boilers which are used for heating the operative department by steam during the cold weather, for supplying hot water throughout the buildings, and for supplying steam to the annealing and die furnaces, and to the drying apparatus. Hard coal is used in these boilers and a pressure of 80lb. per square inch is maintained. The boilers are fitted with connections so that either or both may be used for any of the above services. The steam for heating the building, before entering that system, passes through a reducing valve, so that the pressure is reduced to 10lb. per square inch. The returns from the heating system are led to a hot well, and are returned to the boilers by a duplex feed pump. The boilers may also be fed by means of a Pemberthy injector, or direct from the mains, in case of necessity, and when the steam pressure is below 40lb. per square inch.

The carpenter's shop is in the basement next to the smith's shop, and contains a variety saw, a 12in. wood-turning lathe, and a carpenter's bench. The saw and the lathe are driven from an overhead shaft by a motor, which also drives the shafting for the blacksmith's shop.

Assaying Plant.

This department is situated in the front building and occupies three floors. In the basement the motors and blowers for the furnaces are installed, and here also are stored the acids, chemicals, &c. The furnace room is on the ground floor, and contains three cupel and two melting furnaces, all heated by oil-fuel in conjunction with an air blast. The second floor is occupied by the laboratory and scale rooms.

In this department is an elevator, communicating with all three floors, which may be used either for passengers or for the conveyance of apparatus, acids, &c., to the various rooms. Additional communication between the three floors has also been provided, in the form of a spiral stairway. Fume chambers have been installed in the laboratory and furnace room, together with the necessary chemical and physical apparatus for assay and experimental work.

The Coining Department.

For the purpose of describing the machines used in the actual processes of minting, it may perhaps prove interesting, and more intelligible, if the various operations through which the metals pass while being transformed from ingots into finished coins, are stated in order of sequence, and then are dealt with separately. A short description of each machine and the part it takes in the production of the coins will in each case be given. The operations are as follows: Melting, rolling, adjusting, cutting, marking, annealing, blanching and cleaning, coining, testing.

Melting.—The ingots (of a purity of 999 parts per 1000, or over) are placed with the necessary alloy in the crucibles, and charged into the melting furnaces. There are four of these furnaces altogether, each one taking a No. 30-35 crucible (about 90·110lb. of silver). Crude oil is used as fuel, in conjunction with an air blast. The oil (sp. gr. 32-34 B.) is delivered to the furnaces in very fine streams at a pressure of about 25lb. per square inch, and is mixed with air from a low-pressure blower (air blast about 10 oz. per square inch). The flame does not play directly on the crucible, but first strikes a fire-brick, and is then deflected so as to travel round the crucible, and then to the flue.

These furnaces are very clean, economical, and easy of manipulation. It is usual, in the case of silver, and starting with a cold furnace, for the first round to be ready for pouring one and a half hours after lighting up. After the first round has been poured the furnaces have become thoroughly warmed up, and the subsequent rounds are ready for pouring one hour after charging in. It will thus be seen that in an ordinary working day of eight hours metal can be poured six times from each furnace.

The flues are so arranged that the gases issuing from the furnaces enter a large condensing chamber, where they expand rapidly, and their velocity is reduced. In passing through these chambers the gases strike against baffle plates (the course taken by them being in the form of the letter S placed on its side), by means of which their velocity is still further reduced. Any fine particles of metal which may be carried by them from the furnaces are deposited on the baffle plate and sides of the chambers, and are thus prevented from being carried away through the chimney stack.

This treatment of the gases results in the saving of a considerable amount of metal, as is clearly shown in the annual report of the Director of the United States Mint. From this report it appears that, after six months' working, the value of the metals recovered from the condensing chambers attached to 13 furnaces was no less than $12,900 (£2700).

After the metal has been melted it is poured into cast-iron moulds, forming bars about 24in. long, ½in. thick, and varying in width from 1¼in. to 2¼in., according to the denomination of coin to be made. The newly-formed bars are removed from the moulds as soon as they have become solid and plunged in a weak solution of sulphuric acid; after which they are washed and dried. They are then taken to the shearing machine and revolving files, where the spongy ends are removed, and the rough edges trimmed. They are then ready for the rolling mills.

The shearing machine is of the usual single-ended pattern, such as used in machine shops, fitted with fast and loose pulleys, and driven from an overhead shaft.

There are two revolving files, each consisting of a headstock, with shaft and single pulley between the bearings. On one end of the shaft, outside the bearing, is keyed a circular file of about 6in. diameter and 6in. long. These files are also driven from the same overhead shaft as the shearing machine and revolve at 150r.p.m. The bars from each crucible are kept separate from those from any other crucible, and are marked with distinctive letters and figures, so that their origin can be readily traced at any time. A small piece is cut from one end of the first and last bar from each crucible, and these pieces are forwarded to the assay department for testing purposes. The bars are not operated upon until the report from that department has been received stating that they are within the legal remedy as to fineness. All bars which are above or below the legal standard are remelted with the necessary amount of alloy or fine metal to bring them within the remedy.

All the worn-out crucibles, covers, &c., are ground to a fine powder in a mortar mill; the powder being washed so as to recover any metal that may have been taken up during the process of melting.

The powder is washed twice, after which it is sold by public tender, the tendering firms being allowed to take samples beforehand.

The mortar mill used for reducing the worn-out crucibles, &c., is fitted with an under-driven revolving pan, 5ft. in diameter, has fast and loose pulleys, and is driven from an overhead shaft by a 5h.p. motor. After the powder has been washed, it is dried in a steam-heated drying pan, 8ft. long, 4ft. wide, and 10in. deep. It is then thrown into bins, where it is stored until sold.

Rolling.—When designing these mills arrangements were made to provide for extremely accurate and very fine adjustments for the rolls, for all the driving mechanism to be kept above the floor level (the ground being rock and very hard to excavate), and for economy of floor space.

Each mill is driven by its own motor, through gearing, the general arrangement being as follows: The motor, gearing, and roll housings are all on one bed plate, thus ensuring rigidity and perfect alignment. The first motion shaft carrying the driving pinion runs in its own bearings, and at one end is connected with the motor through a flange coupling outside one of the bearings.

The driving pinion is situated between these bearings, so that the motor is entirely free from any thrust. At the other end of this shaft, outside the other bearing, a small flywheel is keyed. The second motion shaft gears with the shaft driving the bottom roll, and this latter shaft gears through double helical gearing with the shaft which drives the top roll. The rolls are connected with the gearing by means of breaking spindles and muff couplings. The couplings are held up to their work by adjustable wood distance pieces.

The motors run at 600r.p.m., and the rolls at from 40r.p.m., for the breaking-down mill, to 60r.p.m. for the finishing mill. The form of drive described above is found to be very convenient, and to absorb very little power.

The breaking-down mill is driven by a 30h.p. motor fitted with an overload release, which is set to cut out at 50 per cent. overload. The distance between the rolls is regulated by means of worms and worm wheels actuating large, single, square thread screws of ½in. pitch. There are fifty teeth in each worm wheel. The worm shaft is divided in the centre, the halves being connected by means of a friction coupling, so that when it is necessary to "parallel" the rolls, one end only of the top roll may be moved at a time. This worm shaft is actuated by hand wheels at either end, one complete revolution of which closes or opens the rolls .01in. The hand and worm wheels are fitted with indicators and divided circles, so that adjustment of the rolls can be made as fine as .0005in. For ordinary rolling it is usual to work to .001in. at this mill.

It has been found difficult, with the form of adjustment detailed above, to prevent the top roll from jumping when the bar which is being reduced first enters between the rolls. This jump may arise from the three following causes: Firstly, there may be slackness between the roll journals and bearings. Secondly, there may be looseness in the attachments between the bottoms of the big screws and the caps of the roll bearings. Thirdly, there may be wear between the big screws and the threads of the nuts in the roll housings. When it is remembered that the weight of the top roll with its brasses and adjusting gear amounts to about two tons, it can be readily imagined that signs of wear will soon become apparent between these nuts and screws. Various devices have been tried with a view to prevent this jumping of the top roll, a common one being that of heavy weights, situated in a tunnel below the floor level, which act through levers and rods to counterbalance the weight of the top roll and gearing. This method, however, does not entirely overcome the difficulty. In order to avoid excavating for a tunnel, the following arrangement has in this case been adopted, and there is every reason to hope that it will be entirely successful in preventing the jump of the roll: The top of each roll housing has been extended on one side so as to form a hollow casing in which a powerful buffer spring is situated. Each spring is of sufficient strength to take, when half compressed, the entire weight of the top roll with its brasses and adjusting gear. When the top roll is depressed to within one inch of the bottom one, these springs come into full play, and thus keep the big screws which actuate the top roll in close contact with the upper side of the threads in the nuts. There is thus no weight on the bar that is being rolled other than the intentional pinch given to it through the gearing. This arrangement has been thoroughly tested and up to the present the top roll has shown no sign of jumping. The bars so rolled into "fillets" have been carefully gauged and found to be remarkably uniform throughout their entire length. The rolls in this mill are 14in. in diameter and 16in. in length and are driven at 49r.p.m.

The thinning mill is driven by a 20h.p. motor in the same manner as the breaking-down mill. The adjustment of the rolls is also the same, but the gearing, &c., is, of course, of somewhat lighter construction. The rolls in this mill are 12in. in diameter and 14in. in length, and are driven at 50r.p.m. The finishing mill is driven by a 10h.p. motor in the same manner as the others; but the adjustment of the rolls is different. The distance between the rolls is varied by raising or lowering the bottom roll by means of long steel wedges, which are actuated by a hand wheel through gear wheels and fine screws. The hand and gear wheels are fitted with indicators and divided circles, so that adjustment of the rolls can be made as fine as .0002in. The rolls in this mill are 10in. in diameter and 12in. in length, and are driven at 60r.p.m.

The bars from the melting department are first passed ten or twelve times through the breaking-down mill, after which they are annealed in the fillet annealing furnace. They are then passed eight or ten times through the thinning mill and five or six times through the finishing mill, when they should be the correct thickness for the coin that is to be made. For silver and bronze coins rolling is sufficiently accurate, but for gold further treatment is necessary. This latter metal is very dense, having a specific gravity of about 19 as against about 10 for silver and about 9 for bronze. The variation allowed by law from a standard weight is also in the case of gold coins very small. For instance, the standard weight of a British sovereign is 123.274 grains, but the remedy allowance is only .2 grain. If the coin exceeds this limit by even so little as .01 grain it is rejected and remelted. The remedy allowance on silver coins is much more generous weight for weight, being between two and three times as great as for gold.

The fillet-annealing furnace is heated by oil-fuel mixed with steam at 60lb. pressure per square inch. The floor of the heating chamber is composed of three endless chains travelling side by side and driven by sprocket wheels situated at either end of the chamber. The speed at which the chains travel can be varied by means of a speed box attached to the driving motor; so that the time occupied by a fillet in passing through the furnace may be from 4 to 12 minutes. The fillets are laid flat on the travelling chain, five or six side by side, and as they emerge pass through a tank of water so that they are cooled before they come into contact with the air. This arrangement prevents oxidation, and very little if any discoloration is noticeable.

Adjusting.—In the case of silver and bronze the fillets pass from the finishing mill to the blank-cutting machines, but in the case of gold, as before stated, it is found that further adjustment is necessary. The gold fillets are accordingly taken to the draw-bench, where they are drawn between two fixed steel cylinders by means of a dog-clutch which engages with an endless chain. These cylinders are about 4½in. long and ¾in. in diameter, they are highly polished and extremely hard, and the distance between them can be adjusted to .001in. By this means the small inequalities in the thickness of the fillets are regulated, and their variation from standard is reduced to a minimum. The fillets then pass to the blank-cutting machines.

Cutting.—There are three of these machines, each one driven by a separate motor and capable of cutting blanks of all sizes of coins, at the rate of 300 per minute. The punches and beds for all the different denominations are interchangeable, so that little time is occupied in changing from one to another. Each machine is fitted with an automatic variable feed, which can be increased or decreased by multiples of .05in.

After the blanks have been cut from the fillets the skeletons that are left (technically known as "scissel") are cut up into convenient lengths and made up into bundles for remelting.

Marking.—The blanks are next taken to the marking machine, where raised edges are formed round their circumferences. These raised edges protect the impressions which will be given to them later in the coining presses, and thus prevent their being rapidly worn away. This machine is capable of marking 600 blanks per minute. The blanks pass between a circumferential groove, in a rapidly-revolving hard steel disc, and another groove, struck from the same radius, in a fixed hard steel block. The distance between the disc and the block can be varied, so that any size of blank may pass between them. The blanks are then annealed, and thoroughly cleaned.

Annealing.—The blank-annealing furnace is heated in the same manner as the one used for annealing the fillets; but the arrangement for passing the work through is different. The blanks are fed into the machine through a sheet-iron hopper. This hopper is attached to a revolving cast-iron hollow cylinder, on the internal surface of which is cast a hollow thread of very coarse pitch. The blanks follow this thread, moving forward slowly as the cylinder revolves, until they fall through an opening which communicates with a shute leading into a vessel containing water. The flame surrounds the cylinder, which is kept at a red heat during the process of annealing. The time taken by the blanks in their passage through the furnace is regulated in the same manner as in the fillet-annealing furnace. The blanks are cooled before they come into contact with the air, and oxidation is thus prevented.

Blanching and Cleaning.—After having been annealed, the blanks are cleaned in a weak solution of sulphuric acid; washed and dried; they are then ready to receive the impression from the dies. The solution of sulphuric acid is contained in a copper tumbling barrel which revolves at about 40r.p.m., and is so designed that it can be tilted for filling and emptying. After treatment by the acid, the blanks are washed in tanks containing hot and cold water, and are then placed in the drying drum with beechwood sawdust. Beechwood is used for this purpose because it contains no resin, or other ingredient likely to discolour the blanks or make them adhere to one another. The drying drum is hexagonal in section, the sides made of hard wood, and the ends and attachments of brass. This drum revolves at about 25r.p.m., and the blanks and sawdust remain in it for about ten minutes. They are then tipped into a circular sieve, and shaken over the hot plate. The mesh of the sieve is large enough to allow the sawdust to pass freely through the bottom, but small enough to retain the blanks. The hot plate consists of a flat sheet-iron pan about 6ft. long, 4ft. wide, and with sides 6in. high. It is supported on four iron legs, and stands about 3ft. 6in. from the ground. Beneath the pan, and in close contact with it, is a steam coil, by means of which the sawdust is dried, and may be used over again.

Coining.—The coining presses, of which there are three, are of the type in which the pressure is given to the coins through levers and toggle joints. The hard steel knuckles of the toggle joints are of exceptionally large dimensions, so that coins can be struck at the rate of 100 per minute without any danger of them becoming overheated. Each press is driven by its own motor, and arranged so that the drive can be made either through a belt or gearing. The number of blows struck per minute can be varied from 30 to 100 by means of a five-step controller.

The top and bottom dies move up and down, the collar plate remaining stationary. The blanks are placed in the feed tube by the operator, in piles of about thirty. They are fed to the dies, automatically, by steel feeding fingers, which take one blank at a time from the feed tube, and drop it into the collar, at the same time pushing the previously struck piece into the delivery tube.

Hitherto, when coining, it has frequently been the case that for some reason or other a blank has not been placed between the dies at the proper moment. This may occur through the feed tube being empty, or through a bent blank sticking in the tube. In every case the dies have come together ("clashed"), and have been rendered useless. It has been known in a large mint for as many as twelve dies to be "clashed" in one day, representing a cost of not less than $22 (£5) over and above the time taken in changing the dies. As a general rule a pair should be capable of striking about 80,000 pieces before becoming unfit for further use. In order to prevent the possibility of "clashed" dies, a device has been adopted in these presses by means of which the dies do not come together unless a blank has been placed between them. This device consists of a special clutch between the flywheel and the main shaft, which is actuated by an arrangement of levers connected with the feeding fingers. In the event of a blank not being fed to the dies the clutch is released and the column holding the top die is stopped instantly at its highest point, the flywheel continuing to run idle on the main shaft. This attachment takes up no extra floor space and is exceedingly neat and effective. By its means also single strokes can be made by the press; a very convenient arrangement when setting a new pair of dies.

After the coins have been struck they are pushed into the delivery tube and delivered to a bowl placed in the front of the press. The finished coins are forwarded to the examining department, where they are subjected to various tests before they are issued.

Testing.—In the case of gold coins and 50-cent and 25-cent pieces, each one is weighed separately on an automatic weighing machine. The 10-cent and 5-cent pieces are weighed in groups in a hand scale against a standard dollar weight; while the 1-cent pieces are weighed in a hand scale against an avoirdupois pound, which should contain exactly eighty of them.

The automatic weighing machines are very delicate instruments, the weighing being so accurate that the beam, when fully loaded, will turn with .01 of a grain. Each machine will weigh twenty coins per minute. The coins are fed into a hopper by the attendant. One coin is then pushed automatically on to a flat pan attached to one end of the beam, where it remains for three seconds, after which it is pushed off by the succeeding coin. During the time it is resting on the pan its weight determines which one of three shutes it shall drop into when it is pushed off. These shutes lead to three boxes—one for those coins that are too light, a second for those that are too heavy, while a third receives those that are of the correct weight. The latter are taken to the overlooking machine, where they are spread on a travelling band and carefully examined. Any that are found to be discoloured or otherwise imperfect are picked out. The band travels over rollers and on reaching one end of the machine, the blanks are turned over automatically, so that the other side of the coins may be examined.

All the gold coins, and the 50-cent and 25-cent pieces that have successively passed through the foregoing tests are then rung singly on an iron block to find if they have the correct ring, and are not "dumb."

Those coins which have been found to be light or heavy or "dumb" or discoloured, or in any way imperfect, are destroyed in the defacing machine, and remelted. The defacing machine is of similar design to the marking machine, but whereas the groove in the disc of the latter is a plain one, that in the defacing machine is divided into a series of notches, so that the edges of the defective coins are notched all the way round.

The good coins are delivered to the office, where they are counted into bags by the telling machine. This machine automatically counts and delivers into a bag any number of coins as required. When the desired number has been delivered, the machine stops until the trigger is again pulled for the next bag. Any number of coins may be counted on this machine from 100 to 2000; and any size of coin from 50 cents to 5 cents.

In addition to the machinery mentioned above there are several auxiliary machines for various purposes throughout the coining department. Weigh-bridges for weighing truck-loads of raw metal; bullion balances of various capacity, for weighing the metal during the processes of coining; automatic and hand drying cutters, &c.

For the storing of bullion the Mint is equipped with three strong rooms; one in the Mint office, one in the melting house, and one in the rolling and cutting department. These strong rooms are fire and burglar proof, and are fitted with doors each of which has four combination locks controlled by triple time clocks, and arranged so that no door may be opened without the presence of at least two officials. A refinery will shortly be erected in connection with the Mint, in which gold will be treated by the electrolytic process.

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Transformer Testing.

W. M. HOLLIS.

The full-load efficiency of a transformer may be determined quite accurately by the following method, and without employing full load.

The primary is considered as the high-potential coil, and the secondary as the low-potential coil. The losses may be considered as being made up of the core losses, iron losses, including hysteresis and eddy currents, and the copper losses. The core losses are substantially the same at all loads. With the primary open-circuited, measure the watts supplied to the secondary at its normal voltage, or the open-circuit or core losses (Fig. 1). Short-circuit the secondary windings and gradually increase the voltage on the primary until full-load secondary current is obtained. The watts supplied to the primary will then equal the full-load copper losses (Fig. 2). The input at full load is equal to the output at full load plus the sum of the copper losses, hysteresis losses, and eddy current losses. The efficiency is equal to the output divided by the input or to the output divided by the sum of the output and the losses.

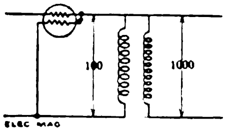


FIG. 1.

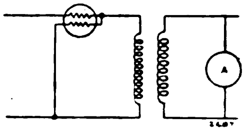


FIG. 2.

If a pair of similar transformers is to be tested or a number of similar transformers, a method may be used for testing them in pairs, an additional transformer, which may be smaller than those under test, being employed during the tests. The method outlined is applicable where transformers of large size are to be tested either with full load or partial load; the losses only are supplied from the mains, so that not only is much energy saved, but large transformers can be tested under full-load conditions with only a comparatively small amount of energy being taken from the mains. In Fig. 3 similar transformers to be tested are represented by X and Y. Similar ends of the secondaries are connected to the mains as shown; of the other similar secondary ends, one is connected to the other main wire through an ammeter, while the other is joined to the same main through a wattmeter and the secondary of a small transformer. The primary of the small transformer is connected to the mains through the regulating rheostat R. The secondary of the transformer X, in whose leads the small transformer is connected, thus has a smaller impressed voltage across it than the second-

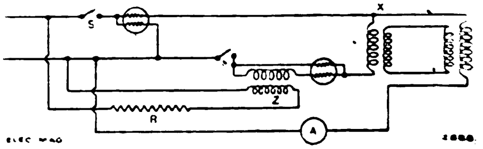


FIG. 3.

ary of the other transformer *Y* under test. The primaries of both transformers are connected so that their e.m.f.s are in opposition and, if the voltages impressed upon the secondaries were the same, no current would flow in these primaries.

By varying the resistance in the primary of the small transformer, its secondary voltage may be varied, and as a consequence the voltage of the branch lead, including the secondary of the transformer *Y*, is also varied. Hence, there are set up circulatory currents in the circuit including the secondaries and in the circuit of the primaries of both transformers *X* and *Y*. The resistance may be varied until the current is such as to give the load at which the losses or efficiency is desired. Switches *s* and *S* are provided, the first in the secondary circuit of the transformer *X*, and the other in the lead from the mains. An ammeter is inserted in the secondary circuit of the transformer *Y*, and a wattmeter is connected in one of the main leads to measure the power input to the system. Another wattmeter is connected in the secondary circuit of transformer *X*.

Considering the secondaries to have similar ends connected to the mains, and the primaries to be connected in series so as normally to oppose each other, then with equal voltages impressed on the secondaries there will be no current flowing in the primaries, since the induced e.m.f.s will then be equal and opposite at each instant. The effect is, therefore, substantially the same, so far as the effect of voltage of the mains is concerned, as if the secondaries were connected to the line and the primaries were open-circuited.

Considering the pairs of transformers from the secondary side, the smaller transformer *Z* sends a current through the circuit, including both secondaries, and such current induces in each of the primaries in such direction as to cause circulatory current to flow in the circuit including the primaries, the effect being similar to a secondary excited with the primary short-circuited. Hence only a small voltage suffices to induce full-load circulatory current in both secondary and primary circuits.

Therefore, the losses only need be supplied from the mains and the small transformer *Z* to give full-load current values in both transformers. Such losses would ordinarily be less than 10 per cent. of the full load of either transformer, and would thus determine the capacity of the small transformer, which must, however, have a secondary capable of carrying the full-load current of the large transformer. The current in the secondary may thus be regulated by varying the resistance *R* in series with the primary of the small transformer. The power loss equals the sum of the readings of the wattmeters minus the loss in the instruments and leads of the secondary circuit. The latter loss may be found and subtracted, if it is of such a value as to affect the results appreciably, by placing a heavy lead around the secondary transformer coils and measuring the watts when the same current as before is passing, switch *S* being open and switch *s* closed. If *V* is the full-load secondary voltage, *I* the full-load secondary current, *W* the watts from the mains, and *W'* the watts from the small transformer, then *V I* is the full-load watts on non-inductive load, and by letting *W''* represent the power loss in leads, instruments, &c., where such loss is so large as to affect the results, the efficiency of both transformers is equal to *V I* divided by *V I* plus *W* plus *W'* minus *W''*, and the efficiency of either transformer is equal to the square root of this quantity.

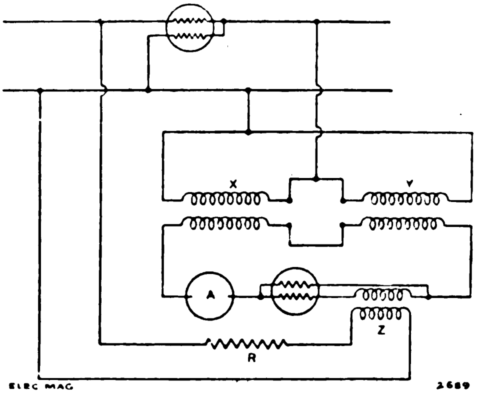


FIG. 4.

A similar method for testing a pair of transformers is shown in Fig. 4. In this case the primaries are connected to the mains, while the secondaries are connected in series through the secondary of a small transformer. The wattmeter connected in one of the mains shows the power supplied from the mains, and the wattmeter connected across the small transformer shows the power supplied by that apparatus. The ammeter shows the current in the secondary circuit. The primary of the transformer *Z* is energized from the mains, and is provided with a regulating resistance *R* for varying the current. The wattmeter across the small transformer then measures approximately the copper loss for the current indicated by the ammeter and that of the leads and instruments. The wattmeter connected in the main circuit measures approximately the iron losses for the two transformers.

As shown in the diagram, the primaries are connected to the mains, and the exciting current for the cores circulates through them. The secondaries are connected so that their e.m.f.s are normally in opposition, due to the excitation from the mains through the primaries, and hence no current flows through the secondaries. The only power furnished to the primaries, therefore, is that due to the core losses or open-circuit losses.

It will be seen that the auxiliary transformer *Z* in the secondary circuit sets up an e.m.f. which tends to circulate current in the closed circuit through the secondaries of the main transformers in series. Such current induces a corresponding circulatory current in the primaries of the transformers under test and the connecting leads, the effect being the same, so far as the excitation from the secondary sides is concerned, as though the primaries were short-circuited. Hence a comparatively small voltage is required from the auxiliary transformer *Z* to cause full-load current to flow in the secondaries and primaries in such including circuits. By measuring the power supplied to the secondary by the transformer *Z*, minus the losses in the instruments and leads, the full-load copper losses corresponding to the value of *I* are obtained approximately. From these values the efficiency may be calculated.

The wattmeter measurements represent the losses for the two transformers, and half of the sum of the readings represents the loss of each transformer. The efficiency, as before, is represented by the quotient of the output divided by the input, or by the watts output divided by the watts output, plus the losses for each transformer. To make a heat run upon a pair of transformers, the primaries and secondaries may be connected as shown in Fig. 4, though the primaries need not be connected to the mains, and an ammeter should be connected in either the primary or secondary circuits.—*Elec. World.*

Construction of a Spark Coil.

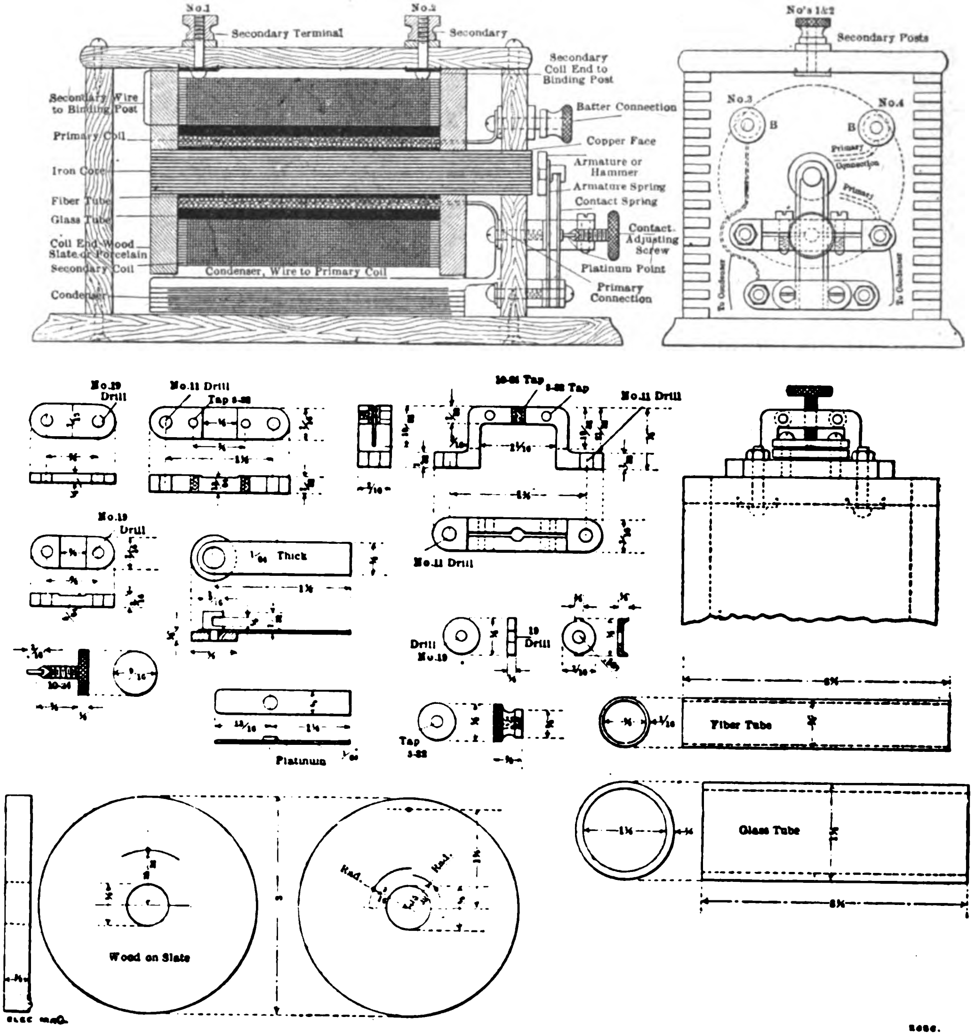
F. C. MASON.

OWING to the growing importance of the gas engine, the subject of spark coils for ignition purposes is becoming one of considerable interest. The general principles of induction coils are generally quite well understood, but if an amateur undertook to build a spark coil without a precedent, he would meet with many difficulties. An auto-spark coil resembles in principle a physician's induction coil (or battery, as it is commonly called), but differs in that it has not the brass tube which slides over the core inside the primary coil to regulate the intensity, is provided with a condenser, and the secondary coil contains more wire, thereby creating a higher potential or voltage. The accompanying illustration shows an auto-coil in section and side elevation, end view, top view, and component parts in detail.

In order to build a coil such as that shown, procure some No. 18 annealed iron wire and cut off sufficient $5\frac{3}{16}$in. lengths to fill a fibre tube of $\frac{5}{8}$in. inside diameter. File off the ends square and solder a plate of copper on one end not over $\frac{1}{64}$in. thick, the purpose of which is to keep the vibrator from sticking, due to residual magnetism in the core.

On the fibre sleeve wind two layers of No. 12 double-covered magnet wire, and encase the whole in a glass insulating tube of $1\frac{1}{8}$in. inside diameter. The thickness of the glass tube is not important, but a tube $\frac{1}{8}$in. thick or more is advisable. Since the glass tube insulates the primary from the secondary coil, its mission is important.

The secondary coil is wound with No. 36 silk double-covered magnet wire, which should be of the best quality; for if the insulation is defective the coil will be useless. Before winding have a ladle of melted paraffin at hand and a brush. Wind one layer of the wire on the glass tube, starting the winding about $\frac{1}{4}$in. from the end of the tube and discontinuing $\frac{1}{4}$in. from the opposite end; then brush on hot paraffin and cover with an envelope of paper. The paper should be fairly thick and of a quality that will absorb hot paraffin readily. Return the wire to the paper envelope and wind another layer of wire, starting $\frac{1}{4}$in. from the end and finishing $\frac{1}{4}$in. from the opposite end. Continue this process, layer by layer, coating each time with paraffin and a layer of paper,



Construction of a Spark Coil.

until the coil is of the proper size. The secondary terminals should be on opposite ends, and both primary terminals on the same end. When the coil is completed soak it in very hot paraffin for an hour, and then let the coil cool in the paraffin until the latter has a mushy consistence, when the coil should be removed and the surplus of paraffin wiped off. The coil head may be made of wood, fibre, slate or porcelain; fibre will be entirely suitable.

For the condenser, procure a strip of paper 4in. wide and about 120in. long, and cut 40 sheets of tin foil 2½in. wide by 4in. long. Fold the paper strip 2⅝in. wide and lay in a sheet of foil, leaving the end protruding $\frac{3}{16}$ of an inch; fold again and put in another sheet of the foil, allowing the end to protrude on the opposite end of the paper, and continue this process until 40 sheets of foil are used up. When finished there will be 20 sheets on each end to connect to. As the tin foil is too delicate for soldering, the connection may be made by forcing a wire against the ends of the foil. The several parts when finished are connected according to the accompanying drawing. Then pour melted paraffin in the box until the coil is submerged; allow this to set and then fill the shrinkage. Place the condenser in position, make the condenser connections, and then fill the case entirely full with paraffin ; smooth off and put on the bottom of case, and the coil is complete.

If the reader never made a spark-coil, this description will give him some idea as to the repair of such coils. The coil, of course, has to be melted out, and should then be placed in a pan in an oven with the door left open, in order that it shall not heat up too rapidly. If the coil does not work, and the vibrator is in good condition, ninety-nine times out of a hundred the secondary terminal is broken, and, of course, this is the most difficult part to get at in most coils.—*Elec. World.*

* * *

DISTILLATION OF TURPENTINE BY ELECTRICITY.*

F. T. SNYDER.

PINE woods contain a series of volatile hydro-carbons having boiling points varying from 130deg. C. to 250deg. C. A mixture of these, including the groups which boil between 155deg. C. and 170deg. C., forms what is commercially known as turpentine. The principal constituent of this turpentine is pinene, with a boiling point of 155deg. C. to 156deg. C.

The process of obtaining turpentine from wood by distillation is an extractive one, in that the turpentine exists in the wood substantially in the form in which it is obtained, and is not a product of decomposition at the time of extraction. At 175deg. C., the pinene of the turpentine begins to break up into a mixture of lighter and heavier hydrocarbons, the decomposition being substantially complete at 270deg. C. It is therefore necessary to distil turpentine within relatively narrow temperature limits. If the wood from which the turpentine is distilled is not heated enough, part of the turpentine will be left in the wood. If it is heated too hot, part of the turpentine produced will be destroyed. Many of the products formed in breaking up turpentine have strong odours, and a small percentage materially affects the selling price of the turpentine produced, as the smell nauseates the painter using the turpentine. It requires a certain drop of temperature to cause the heat needed to flow from the exterior to the centre of a turpentine retort, and this further reduces the narrow range of temperature available.

It has been known for many years that the fir wood of the North Pacific Coast contains a considerable quantity of turpentine, and efforts had been made to utilize it as a basis for the commercial production of turpentine. The principal difficulties encountered were those inherent in the close regulation of temperature necessary. Some years ago the obvious possibility of close temperature regulation obtainable with heat from electricity suggested the use of heat from electricity in the distillation of turpentine from this fir wood. At Vancouver, British Columbia, a considerable supply of waste fir wood was available, in the form of saw-mill refuse, and electricity from waterpower was available at a low cost. An experimental electric turpentine plant, with a capacity of one-sixteenth of a cord, was erected and tested, and subsequently reported upon by Dr. T. H. Bray of the Massachusetts Institute of Technology. As a result of Dr. Bray's report a commercial plant, with a capacity of three cords per day, was erected, and has been in operation at Vancouver since July of last year.

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* Paper read before the American Electrochemical Society at Albany, N.Y., April 30, 1908.

The wood supply for this plant is brought in by barge, from neighbouring saw-mills, and landed at a dock adjoining the plant. On this dock the wood is filled into cans, which are wheeled into the plant, picked up by an overhead crane and dropped into a brick retort, forming one of several which are placed together to reduce radiation. The top of the can forms a flange, which dips into a groove around the top of the retort, filled with tar, forming a gas seal when the can is in the retort. Electricity at 110 volts is carried through wrought-iron strips threaded through the brickwork on each side of each retort. The current supply for each retort is controlled by a switchboard of ordinary type, which also holds the direct-reading pyrometers, one of which registers the temperature at the outside of the can and one the temperature at the centre of the can, showing the maximum and minimum temperature conditions in the can. The leads of these pyrometers end in flexible extensions on the top of the retorts which can be changed from can to can.

The turpentine vapour is taken from the retort through a removable copper outlet pipe. This outlet pipe leads to a condenser which consists of an upright copper pipe, down which a spray of water is passed through the ascending turpentine vapour, and which terminates in a tank at the bottom. The tank serves as a separator for the condensed turpentine and water, the turpentine readily floating to the top of the water. The excess water from the spray is withdrawn from the bottom of the tank, and the turpentine taken off from the top of the tank into a storage system.

The brickwork of the retort, when a can newly filled with wood is put in it, is at a temperature of about 250deg. C. The cold can rapidly absorbs heat from this brickwork, the temperature of the brickwork being kept up by a current of 400amp., which is put through the resistance strips for about two hours. During this time the temperature at the outside of the can rises from 75deg. C. to 130deg. C., at which turpentine begins to come off, and at which time the centre of the can is at 45deg. C. The current is then shut off, and the temperature of the can slowly rises by absorption of heat from the brickwork for two hours longer, when the temperature has reached 150deg. C. on the outside of the can, and 205deg. C. in the centre of the can, and the turpentine has been substantially all removed. In practice, it is found that from 90 to 95 per cent. of the turpentine in the wood, as determined by analysis, is removed during this interval. While the turpentine is coming off, the pitch in the wood melts and runs down to the bottom of the can and out through perforations, and is collected in the bottom of the retort, from which it is drawn off, at the end of the run, into the barrels in which it is shipped.

It will be noted that the temperature of the interior of the can at the end of the turpentine run is hotter than the outside. This is due to the heat which is beginning to be liberated by the decomposition of the hydro-carbons in the wood. At this point the can is lifted by the overhead crane from the turpentine retort and put into the adjoining retort, a new can of raw wood taking its place in the turpentine retort. In its new position the original can of wood from which the turpentine has been extracted is connected up by another copper outlet pipe to the adjacent condenser. This change of retort and piping keeps the turpentine condenser and piping from being fouled by tar oil or tar products.

Due to the continued decomposition of the wood the temperature steadily rises without further use of electricity and the resulting decomposition gives a product known commercially as "tar oil" and which comes off as vapour and is condensed. The other product of this decomposition is wood tar, which trickles down as the rosin did in the turpentine retort and is collected in the bottom of the tar retort. It is found in practice that this tar tends to break up at the final temperature of the tar retort, and it is consequently drawn off continuously during the tar run, into the barrels in which it is to be shipped.

At the end of three hours of the tar run, the temperature in the centre of the can has risen to 375deg. C., and tar oil and tar stop coming off. The can is then lifted out and stood on a sand floor, which makes an air seal with the lower edges of the can and protects from combustion the contents of the can, which now consists of charcoal. When the can and its charcoal contents are cool, which takes about three hours, the perforated bottom of the can is tripped and the can lifted, allowing the charcoal to fall out. This charcoal is then put in sacks, as required by the trade which consumes it.

Five products are produced from the wood—turpentine and rosin in the turpentine retort, tar oil and tar in the tar retort, and a residual product of charcoal. The amount and kinds of the products derived from any supply of wood depend on the character of the wood. The following will indicate the results which are being secured from the British Columbia coast fir per 1000lb. of wood:

Turpentine ...	... 6.7	gallons
Rosin ...	... 168	pounds
Tar oil ...	... 5.1	gallons
Tar	... 68	pounds
Charcoal ...	... 323	pounds

It may be noted that this charcoal, being retort charcoal and cooled out of contact with air, is tough and suitable for special purposes. The amount of wood held by a can varies with the quality of the wood, but averages at Vancouver about 1000lb. The electricity used per can is about 90 kilowatt-hours, and costs, at Vancouver, 9d. per can of wood.

The plant is operated by one man on each shift, there being two 12-hour shifts per day. When the wood is large, an extra man is employed on the day shift to split it.

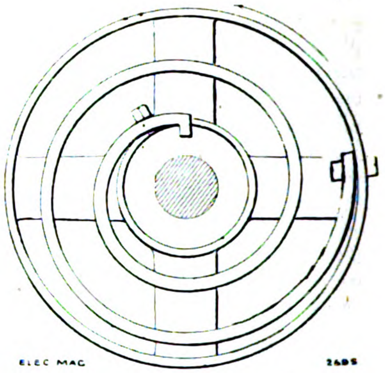
* * *

Device for Steadying Gas Engine Drive.

M. W. PULLEN.

A FOUR-STROKE-CYCLE gas engine makes only one power stroke in two revolutions. The result is that with a hit-and-miss governor the angular velocity is a variable quantity, particularly if the flywheels of the engine are light, or the governor mechanism poorly adjusted. If the engine has a throttling governor results are much better so far as steady speed is concerned. However, unless the engine has heavy flywheels, or some similar means are used to steady the angular velocity, considerable variation results, and if the driven machine be an electric generator the voltage will vary considerably.

The writer has installed a few private electric-light plants, using petrol engines as motive power. One of these outfits has a 3h.p. petrol engine, having a throttling governor and very heavy flywheels of comparatively large diameter. The generator is belted directly from the flywheel of the engine and gives entire satisfaction so far as the quality of light obtained is concerned. This plant has been in operation for four years.



ARRANGEMENT OF FLEXIBLE PULLEY.

The main objection about such a system is the expense of the engine, being a good deal more than the ordinary engine with a throttling governor and light flywheels. The above objection was overcome and some advantages gained in another installation of the same size, so that the extra-heavy wheels were not needed. In this plant it was desired to run a power pump as well as the generator with the engine. For this reason a countershaft was used, and the pump and generator belted from it. It was thought that the extra belting and pulleys would absorb any variation of speed in the engine, but they did not, although the engine ran at 350r.p.m. and the countershaft at about 450r.p.m. In order to remedy the trouble and still avoid using an extra balance wheel on the countershaft, resort was made to the device shown in the accompanying illustration. The cure for the trouble was radical and much cheaper than a balance wheel.

The driven pulley on the countershaft is not set solidly to the shaft by means of set-screws, as is usually done, but is loose, except for the spiral spring, shown in the figure, which connects the rim of the pulley to a collar which is solidly secured to the shaft. The spring is made of carriage-spring material and is about 1$\frac{1}{2}$in. wide by $\frac{5}{16}$in. thick. The spiral makes about one and three-quarter turns. With fewer turns the springs were found to break too easily, but the one of these proportions, as shown, has lasted for the past five years.

The action of the device is simple. When the engine slows up on compression the spring gives one way, the momentum of the armature, shafting, &c., keeping the motion uniform. The driven pulley and shaft will then be at their extreme angularity back from the normal position at maximum compression. The power stroke now takes place and the relation of the pulley to the shaft is the forward extreme, the momentum of the armature and other parts again helping out the action as before, thus absorbing the violent fluctuations of angular velocity and steadying the electric lights.

When the machinery is not in use a person can readily vary the position of the shaft with respect to the driven pulley about 60deg. by rotating the generator pulley with one hand. The amount of variation under running conditions of course is not known, but it is ample for the purpose intended.

Apart from the advantage of steady lights gained, the machinery is easier to start since in cranking the engine the spring gives a little and the engine is under motion before the generator moves, being somewhat after the fashion of a locomotive starting a train car by car. The explosion of the first charge in the engine is partly taken up by the spring, and so there is much less strain on the belts at this severe period than with a rigid connection. The belts run much more smoothly also—in fact as smoothly as many belts the writer has seen in steam-driven plants.—*Power.*

RECENT PROGRESS IN TUNGSTEN METALLIC FILAMENT LAMPS.*

H. HIRST.

The first commercial metallic filament lamp was the osmium lamp, invented by Auer von Welsbach in 1898, and put on the market in the following year. Its regular commercial supply commenced in 1902.

In this lamp the filament is made of metallic osmium, which has a considerably lower specific resistance than carbon. Due to this increased conductivity doubts were expressed as to whether osmium lamps could be manufactured for the usual voltages.

Osmium lamps consumed per candle-power 1½ watts. Useful life over 1000 hours. Decrease of candle-power during that period scarcely any. They were hence much superior to carbon lamps taking per candle-power 3½ watts, and after a life of 800 hours decreasing in candle-power 20 per cent.

At first the osmium lamps could only be produced for 37 volts, which necessitated the connection of three lamps in series on a 110-volt circuit. The lamps were very fragile, and had to be burned in a perpendicular position. Their cost was about ten times that of a carbon lamp, due largely to the limited quantities of osmium available.

This did not prevent millions of these lamps being manufactured, but it was evident that it would be impossible to produce them in the quantities required to supply all Europe, which would need between thirty and forty million lamps per year.

During the following three years the osmium lamp was further improved and made available up to 77 volts, enabling two in series to be used for 110 volts, and three in series for 220 volts.

In January, 1905, the tantalum lamp appeared on the market. It possessed the great advantage that it could be burnt in any position and on a 110-volt circuit. Its economy was slightly less than that of the osmium lamp and the useful life of the filament was considerably shorter. It was found that this life, when the tantalum lamp was used on alternating-current circuits, was so low that the makers did not recommend their lamps for these circuits. It must, however, be said that in spite of this disadvantage the tantalum lamp would have been looked upon as the lamp of the future had there not been a serious competitor to it even before it was a commercial article.

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* Abstract of Paper read before the Institution of Electrical Engineers, London, May 21st, 1908.

Many inventors had been working independently on the improvement of the electric incandescent lamp, using metals with high melting points, such as osmium, chromium, molybdenum, tungsten, &c., and it is interesting to note the various suggestions as to methods of manufacture which appear in the Patent Specifications.

Thus Lodyguine proposed to coat a suitable core of platinum, silver, or carbon with these metals, but he could not obtain incandescent bodies consisting of the pure metals of high fusing-points, as evidently he did not know how to eliminate the interior core of platinum, silver, or carbon on which the filament was built up.

The superiority of tungsten over other metals such as osmium, molybdenum, chromium, zirconium, thorium, tantalum, vanadium, niobium, &c., for the construction of incandescent filaments, has now been ascertained by research, but was not proved at the time when Lodyguine made his investigations.

In 1904 Siemens and Halske endeavoured to extend their drawing process, which had been successful with tantalum, to tungsten, thorium, &c. The brittleness of tungsten and its want of ductility rendered the process inapplicable, and apparently Siemens and Halske have not up to the present time succeeded in producing lamps with drawn tungsten wire.

It was also in 1904 that Drs. Just and Hanaman applied for a patent for incandescent bodies consisting of pure tungsten. This is the first English patent describing the manufacture of pure tungsten filaments—all previous inventors had failed to produce metallic bodies from this element which were free from oxides, carbon, or carbides.

Quite independently of these inventors, the Deutsche Gasglühlicht Aktiengesellschaft (the Auer Company) applied for a patent which covers a process for the manufacture of pure tungsten filaments. In 1906 and 1907 a large number of British patents were granted both to the Deutsche Gasglühlicht Aktiengesellschaft and to Drs. Just and Hanaman which describe further improvements in the manufacture of tungsten filaments.

The patents mentioned cover what is known as the "paste" process of producing tungsten filaments—another method called the "coating" process was protected by Drs. Just and Hanaman in a British patent of 1905.

These fundamental patents appear to protect the processes according to which tungsten filaments can be manufactured commercially at the present time.

Patents of other inventors are :—

Heany (American patent No. 839,585), who proposes to use an alloy of tungsten with titanium.

Kuzel (British patent No. 28,154 of 1904) suggests the manufacture of glowing bodies from colloidal metals.

British Thomson-Houston Company (British patent No. 18,749 of 1906 and subsequent patents) describes the manufacture of filaments of tungsten with the help of volatile metals or alloys, chiefly amalgams, which could be drawn into wire. It will be interesting to watch the progress of this suggestion.

Zerning (British patent No. 2554 of 1906) claims the use of hydrogen and nitrogen compounds of tungsten as the materials from which to construct tungsten filaments.

The hydrogenous compounds of tungsten have apparently never been described by a chemist, and the statement of Sir Henry Roscoe still stands. In his famous work, "Elements of Chemistry," he refers to the treatment by Berzelius of tungsten trioxide in a current of hydrogen. The result of the experiments of this famous scientist, which were confirmed by his French contemporary, Moissan, was the production of nothing but pure tungsten powder without any trace of hydrogenous compound being formed.

As Zerning's experiments were directed towards the same object, it would denote a wonderful achievement if he should have produced a result which is not described in any scientific work and which the above eminent authorities found to be impossible.

The nitrogenous compounds are well known, and it is proved that they cannot exist at the high temperature at which the filaments have to be burned. The patent description is not very clear, but indicates that Zerning intends to make use of the "paste" process, thus producing filaments containing probably carbon or carbide.

After a careful consideration of all the patents on the subject, the author believes he is right in maintaining that of the multitude of processes that have been applied for and tried since the first application of the Deutsche Gasglühlicht Aktiengesellschaft and the Just and Hanaman patents, these two alone have during the last two years produced to the world commercial and useful lamps; that is, lamps of such characteristics as regards current consumption, life, and light as to inaugurate a new epoch in the electric lighting industry.

It has been ascertained that all metallic filaments burning at a consumption of one watt per candle have been made with tungsten filaments. If ever so small percentages of other substances are added to the tungsten, the economy and useful life of lamps with such filaments suffer immediately. "Osram" is the name under which the Auer Company introduced the first commercial tungsten metal filament lamp.

The osram lamp is manufactured by the "paste" process, the principle of which consists in preparing from solid substances, such as the metals themselves in the most finely divided form, a paste with binding or stiffening agents, such as the gums, dextrine, and other similar bodies. Such a mass has the consistence of putty, and is then squirted through a very fine orifice in a diamond, with a pressure of several tons per square inch. The result of the squirting operation is that one obtains a somewhat moist thread, which, however, has enough coherence to be formed into filaments that do not break while being dried.

The filaments are first heated under exclusion of air and then possess sufficient strength to be held in metal clamps. They are then subjected to the passage of an electric current which raises them to a high temperature causing the filaments to sinter. The process of sintering is carried out in gases which chemically attack all the constituents of the binding agent without the metal being affected, so that eventually a filament of pure metal remains. This filament is dense and homogeneous, but being obtained by a sintering process it is different in structure from the still denser metal which would be obtained from a melted mass.

Auer von Welsbach describes a method for the manufacture of an electrical illuminating body of osmium by sintering the most finely divided metal at such a high temperature that platinum would evaporate, which temperature destroys the binding material which had been used in the manufacture of the threads. The filament so obtained withstands very high temperature, but it is still of a more or less spongy or porous constitution; very metallic, but nearly solid. The difference of the filament of the osram lamp, which is pure tungsten metal, from the filaments of the osmium lamp, shows itself by the following characteristics:

Owing to the higher melting-point of tungsten an osram filament will stand a temperature at least 100deg. C. higher than the osmium filament. Their *specific resistance* and *resistance coefficients* differ and there is considerable difference in their *radiation properties*. The *colour* of the osram filament is a steel to a silver grey, whilst the osmium filament has a bluish-grey appearance.

When preparing osram filaments for lamps of 120 volts, 22 to 27c.p., burning at an efficiency of about 1.1 watts per candle power, taking 0.2 to 0.25amp., the diameter of the filaments is 0.03mm. The jet from which this filament is squirted is, of course, much larger. As an example:—

The diameter of the jet at point of issue from the diamond is about	0.055mm.
The thread after being squirted shrinks to when dried	0.050 ,,
After it has been heated to a red heat under exclusion of air it becomes a very porous filament with a diameter of	0.045 ,,
When this is sintered by the passage of an electric current which raises it to the brightest white heat its length is reduced and it finally shrinks down to a diameter of	0 030 ,,
The shrinkage is caused by the removal of the carbon and other material forming the organic binding medium which originally amounted to ... ... of the volume of the paste.	84 per cent.
It follows that during the whole process 84 per cent. of the original volume must disappear, and the shrinkage corresponds to a linear contraction of	55 ,, ,,

It is easy to alter the amount of shrinkage by selecting suitable proportions of the binding medium or by adding volatile substances which disappear on heating.

During this heating process the filament is fastened in clamps and placed in globes or other arrangements containing certain gases. The heating is effected by the electric current to a gradually increasing amount, and while the thread decreases in length and diameter it at the same time allows the passage of increased currents. This is due to the sintering of the particles and also to the filament being freed from carbon, which even in minute quantities increases its resistance. The process is controlled by the operator, who has a voltmeter and ammeter to guide him. The current increases rapidly at first, but reaches a constant value within a few minutes. This is common to all sintering processes, and the same phenomena are observed with osmium, iridium, or molybdenum filaments.

The filament so obtained is elastic but brittle; that is, the osram thread, 0.03mm. diameter, can be bent into a loop of about one centimetre diameter without breaking. After this bending it returns to its original form. Each filament is fastened on to its leading-in wires without the application of any paste.

This is carried out in the following way: The end of the leading-in wire is melted down to a small globule by means of an electric arc. This globule holds the filament securely, and the resistance from the passage of the current from the leading-in wire to the filament is negligible.

The evacuation of the lamp is carried out in the same way as with carbon filament lamps. Any process, mechanical or chemical, is suitable, but it is found that any traces of the gases occluded in the tungsten filament escape much more slowly than in the case of the carbon filament. The result is that the evacuation process requires a longer time with the osram than with the carbon filament lamp.

The other method of constructing tungsten filaments was developed by Drs. Just and Hanaman simultaneously with, but quite independently of, the Deutsche Gasglühlicht Aktiengesellschaft. Their lamp was introduced commercially under the name "Just-Wolfram." They use what is known as the "coating process" as described in the British patents 11,949 of 1905 and 3684 of 1906. This interesting process is carried out as follows: Ordinary carbon filaments of very small diameter, 0.02 to 0.06mm., are raised to a bright red heat by means of an electric current in an atmosphere of volatile tungsten compounds in the presence of hydrogen. The compounds most used are the chlorides and oxychlorides of tungsten.

The heat of the filament causes the hydrogen to reduce the volatile metallic compounds, depositing the metal in homogeneous condition on the carbon filament.

A later patent discloses a process whereby three or more filaments are coated in series at one operation. After the filaments have been coated in this way their transformation into pure tungsten filaments is carried out as follows:—

The filaments are submitted to the action of an electric current in an atmosphere of highly rarefied inert gas, such as, for example hydrogen at a pressure of about 20mm., until they show the clearest white incandescence. This process causes the carbon to combine with the tungsten surrounding it, forming a carbide. This change is so complete that in the resulting filament the cross-section is tubular and no carbon can be distinguished under a microscope at the point of fracture. The filaments so obtained, containing carbon (mostly as carbide), present a glittering white metallic appearance.

In the next process they are raised to a high temperature through the passage of an electric current while they are surrounded by a mixture of hydrogen and a little steam. This causes the carbon to be oxidised by the same reactions which go on in the water-gas process. The carbon may, however, be eliminated by any other method which gives a resulting filament entirely free from carbon. Further improvements of this process, first described in the British patent 11,949 of 1905, have been disclosed in the British patent 3684 of 1906.

Drs. Just and Hanaman have also obtained patents (British patent 9349 of 1906) protecting the process of mounting their tungsten filaments to the leading-in wires. This is effected by means of a paste consisting of finely divided tungsten metal mixed with coal tar or gum. These paste mounts are dried and finally made red hot by any suitable means before the filament is heated in the bulb. The supports used in these lamps are made of suitable metal.

Exhausting is done in a manner similar

to that employed for carbon lamps. The filaments made by this process have a light grey silvery appearance and a little smoother surface than those made by other methods; in fact, they most nearly approach the appearance of a drawn wire.

Though this process is entirely different from the "paste" process, the final result in each case is a pure, sintered filament of tungsten metal. The sole difference is that the filament made by the Just and Hanaman process is tubular. As regards economy, the tungsten or osram lamps produced by either of the above-described processes have identically the same characteristics.

It has been proved that these lamps will burn for from 1000 to 2000 hours with a consumption of about 1 watt per candle-power, without any appreciable falling off in the candle-power. Of all the metals which have been experimented with up to now only pure tungsten has such a life.

In economy the result is also better than has been obtained with other filaments, thus:—

The osmium filament takes 1.5 watts and the tantalum 1.7 watts for direct current and somewhat more for alternating.

Output and Efficiency.

In the following comparisons between the osram and carbon lamps the Hefner candle-power has been adopted in every case, as this has so far been the standard mostly used when metallic filament lamps have been discussed. At the present it is found next to impossible to try to standardise metallic filament lamps per candle-power. It would make the lamp commercially impracticable.

The metallic filament lamps resemble in characteristics more the incandescent gas mantle than carbon filament lamps, and there is, therefore, nothing unreasonable in demanding a similar treatment for them to that accorded the incandescent gas mantle. The normal efficiency of both osram and Just and Hanaman lamps of all voltages is about 1 watt per candle-power. At such efficiencies they burn 1000 hours without a perceptible decrease of candle-power.

The following figures give a comparison between the energy taken and power radiated from the surfaces of osram and carbon filaments:—

The filament of a 25c.p. osram lamp consuming per mean horizontal candle-power 1.1 watts has a total surface of about 50 sq. mm., which equals per candle-power 2 sq. mm., or per watt of supplied energy, 1.8 sq. mm. A good surfaced carbon filament consumes per mean horizontal candle-power 3.5 watts = per candle-power 5.5 sq. mm., or per watt of supplied energy 1.57 sq. mm. It results, therefore, that 1 sq. mm. surface of osram filament gives 0.5c.p., and consumes 0.55 watt. 1 sq. mm. surface of carbon filament gives 0.182c.p., and consumes 0.63 watt.

Radiation.

It will be seen from the above figures that the osram filament radiates only 87 per cent. of the energy radiated by an equal surface of the carbon filament, but gives 275 per cent. of the light given by the carbon filament.

If the kind of radiation were the same in both cases the carbon filament ought to get hotter than the osram filament by about 60deg. C., because of the higher total radiation per unit of surface. On the other hand, considering the greater light emanating from the osram filament, it ought to exceed the carbon filament by about 200deg. C.

These contradictory conclusions show clearly how different is the radiating power of the osram filament as compared with the carbon filament. The latter behaves much more like the "black body" of the radiation theory.

From approximate calculations the temperature of an osram filament burning at 1.1 watts per candle-power is about 250deg. C. higher than that of a carbon filament burning at 3.5 watts per candle-power. If a carbon filament were to be overrun to such an extent as to consume only 1.1 watts per candle-power, its temperature would then have to be raised by 360deg. C.

The favourable radiating properties of the osram filament, therefore, mean that its temperature is 100deg. lower than that of a carbon filament of the same efficiency. If it were not so possessed of this radiating property it would have to be burnt at an efficiency of 1.5 to 1.6 watts per candle-power, in order that it might have the same life it actually possesses at 1.1 watts per candle-power.

A further favourable property possessed by all tungsten filaments is their high positive temperature coefficient of electrical resistance. If one takes the resistance of carbon, tantalum, osmium, and tungsten filaments at ordinary temperatures, the resistances at those temperatures, which, in a vacuum, correspond to 1.5 watts per candle, will be as follows :—

For a carbon filament ...	0.55 of the original.
For a tantalum filament...	5.70 times.
For an osmium filament...	8.50 times.
For a tungsten filament ...	11.00 times the original.

At temperatures of about 2200deg. C. absolute, each increase of temperature of 10deg. increases the resistance of a tungsten filament about 0.45 per cent.

If the pressure is raised from 100 to 104.5 volts, the current rises from 1 to 1.027amp.

For a carbon filament the amount of the increase would be from 1 to 1.05amp.

The total energy supplied, therefore, rises in the former case about 7.3 per cent., and in the latter about 9.7 per cent.

Near the normal conditions the light of a carbon filament lamp rises and falls with the 6.3 power, that of a tungsten filament lamp with the 3.6 power, of the voltage.

The latter differences are too great to be explained by the increase of energy caused by the change of pressure.

The small changes in the light of the osram lamp, as compared with a carbon lamp for the same change of voltage, can only be completely explained by the supposition that with a change of energy the radiated light is altered in a different way with the two lamps. A simple calculation shows that near the normal efficiency the light of a carbon lamp changes with the third power of the energy, whilst such change for an osram lamp progresses with 2.3 power of the energy. These proportions have a very important practical consequence, which is clearly shown by the following table :—

	Osram.	Carbon.
Increase of light due to 10 per cent. increase in voltage ..	36 per cent.	84 per cent.
Decrease of light due to 6 per cent. decrease of voltage ..	21 ,,	34 ,,

It will be seen that the osram lamp is much less affected by changes in voltages. Thus, if the pressure is decreased by 6 per cent. from the normal, the light from a carbon filament lamp is reduced so much that it is a considerable drawback, whilst the reduction of light from the osram lamp is not considerable.

High-voltage Lamps.

High-voltage metallic filaments of the osram type have recently been put upon the market, manufactured both by the D.G.A. and the Just-Hananan processes. A number of these have been tested in commercial use and under special conditions to ascertain their life. From the results obtained, the average life of a 1-watt 1c.p. lamp seems to be between 800 and 1000 hours. During this period there is no appreciable drop in candle-power, and the lamps have shown themselves to be equally good as the low-voltage osram or Just lamps. These high-voltage lamps, made for from 200 to 250 volts, require double the number of filaments used in the low-voltage lamps. It is evident, therefore, that they cannot be produced for small candle-power. Up to the present 40c.p. to 50c.p. is about the lowest unit that has been obtained in a commercial lamp, and some extraordinary development or discovery will have to be made before that candle-power can be largely reduced.

The Use of 110-volt Lamps on 220-volt Circuits.

In so far as the lamp is different from the carbon lamp, it will, therefore, always be necessary to rely on series running whenever low units of light are required on high-voltage circuits; thus, for public lighting (especially for the lighting of large spaces), the convenience of one lamp will be apparent, and people will stretch a point to use 50c.p. for such purposes whenever they can; but for the use of private houses and confined spaces it will always be necessary to revert to lamps burning in series.

To meet this demand, elaborate arrangements have been made at the Osram works for testing lamps that will run in series. They are tested to one-hundredth of an ampere, and sorted out in from five to seven series numbers according to the type of lamp and carefully marked, and the reference numbers (ranging from, say, 28 to 38, which are marked on the caps of all lamps singled out for series burning) practically mean the consumption of current is 0.028, 0.029, 0.030, 0.031, &c., of an ampere.

This running of osram lamps in series can be avoided to a very large extent in those areas where the supply is given on the alternate-current system. In such cases, where the wiring of the premises to be lighted is carried out on the sub-circuit principle (as recommended in the wiring rules of this institution), it is an easy matter to group up the circuit into two halves, and to connect these halves in series. If it could be ensured that there would be always an equal number of lights burning in each of the groups of circuits connected in series in this way, nothing further need be done. As this is not possible in most cases, an auto-transformer has to be added. These tungsten filament lamps burn equally well on either continuous or alternating current, and are quite independent of both frequency and wave form.

The Effect of Metallic Filament Lamps on Supply Systems.

Fears have been expressed by some electrical engineers that the introduction of these osram lamps will seriously affect the finances of supply undertakings. Exactly the same fears were expressed by gas engineers when Welsbach mantles were introduced, which enabled the gas required to produce a given quantity of light to be reduced to one-third of that previously used. These fears proved groundless, and the demand for gas increased instead of decreased. The author feels confident that the same result will follow the commercial use of the metallic filament lamp. It seems likely that the introduction of these lamps will mean an increase of 100 per cent. in the unit adopted for electric light. 16c.p. carbon lamps will be replaced by 25 to 35-watt tungsten lamps, and those places in which a low illumination is desired will still be supplied with carbon filament lamps of 2½, 5, and perhaps 8c.p. As it is not practicable at present to make osram lamps for 110-volt circuits of a lower candle-power than 25, it is likely that in small rooms greater illumination will have to be used. Where larger spaces have to be lighted, it is easily possible to obtain the present illumination by using fewer lamps, but the author believes that with the cheaper light the general tendency will be towards higher illumination. Generally speaking, he does not think that the metallic filament lamp will decrease the current consumption of existing consumers to the extent expected, but will, instead, lead to a large increase in the amount of illumination. At the same time the high efficiency of the lamp, compared with all other forms of lighting, will turn the scale in the favour of the use of electric light rather than of other illuminants. Station engineers will find that the increased load from new consumers will more than make up for the decreased consumption of existing ones. This conclusion has already been proved to be correct by Mr. C. P. Sparks, Mr. A. H. Seabrook, and others.

As has been the case with so many new inventions, so the tungsten lamp on its introduction had to run the gauntlet of many reproaches on the part of the more conservative elements in our profession. The author thinks it well to allude as fully as possible to what have been termed the disadvantages of the lamp. Amongst these is the burning in vertical position, which up to now has been insisted upon by the manufacturers. This problem is already solved in different ways, and lamps can now be supplied to burn in any position.

The price of these lamps is for the moment a trifle higher, but before many months they will be supplied at the same price as the others.

The price itself is naturally held up as a disadvantage, especially when a consumer is displacing old lamps for new ones. The outlay then appears serious, but Table II. shows that the saving in current for given illumination rapidly wipes off this expenditure.

Much has been made of the brittleness of the metallic filament and of the percentage of breakage in certain instances; from the moment it was understood how to pack the osram lamp the breakage in bulk has been a negligible quantity. It now only affects the supply of the lamps in small parcels of one half-dozen to one dozen. This problem is being dealt with, with every prospect of an early success.

Another point about which there has been considerable outcry is the blackening of individual bulbs which occasionally occurs. It is at present thought that this blackening is due to some extent to the great sensitiveness of the filament to small changes in vacuum. Other theories exist as to the cause of this, but what for the moment mainly interests the users is that if a lamp is going to blacken it usually happens at a very early period of its life, when the makers are prepared to deal with the matter generously. It is quite different in this respect to a carbon lamp, in which a

TABLE II.

Life Test Results.

No. of Test.	Type.	Cost per Lamp.	Tested by	Starting.		Efficiency in W./C.P.	Number of Lamps.	Duration of Test.	Average Useful Life.	Mean Efficiency.	Average C.P.-Hours.	Cost per 1000c.p. hours.		
				Watts.	C.P.							Re-newals.	Energy at 4d. per Unit.	Total.
	Low Voltage.	d.						Hrs.	Hrs.	W./C.P.		d.	d.	d.
I.	Osram	48	Faraday House	35.7	36.3	0.99	12	2000	1520	1.12	48,700	0.98	4.48	5.46
II.	Osram	48	Westminster Testing Laboratory	35.8	29.7	1.22	12	1500	1360	1.29	36,600	1.31	5.16	6.47
IIA.*	Osram	48					12	3350	2850	1.42	70,800	0.67	5.68	6.35
III.	Osram	48	T. R. Charlottenburg	34.7	1.0	1.12	?	1000	1000	1.11	31,100	1.54	4.44	5.98
IV.	Osram	48	Robertson E. L., Ltd.	35.0	27.7	1.26	6	1800	1720	1.36	45,600	1.06	5.44	6.50
V.	Wolfram	48	Robertson E. L., Ltd.	38.0	30.7	1.24	2	1000	1000	1.27	28,900	1.66	5.08	6.74
VI.	Tantalum	33	Westminster T. L.	39.1	22.0	1.78	6	1000	700	1.84	15,000	2.19	7.36	9.55
VII.	Carbon	12	—	59.0	18.7	3.15	10	1000	1000	3.25	18,000	0.67	13.00	13.67
	High Voltage.													
VIII.	Wolfram	90	Robertson E. L., Ltd.	63.4	53.7	1.18	10	880	720	1.12	42,500	2.12	4.48	6.60
IX.	Carbon	12	—	68.0	18.9	3.6	10	1000	1000	3.95	18,200	0.66	15.80	16.46

NOTE.—For the purpose of comparison *all* the above results have been expressed in terms of the "Hefner" unit of candle-power.

* This is a continuation of Test II. to 3350 hours to show that it pays to burn osram lamps to the limit of life.

blackened bulb means as a rule that the lamp has been kept on circuit for an indefinite period, far exceeding its useful life.

Having dealt with these points, the author calls attention to the other data on Table II. and to the following curves (Figs. 1, 2, 3, and 4), showing some characteristic tests of osram, tungsten, and tantalum lamps made by various independent testing authorities.

The samples of osram lamps were selected at efficiencies corresponding to the limits of sorting, that is, 1.0 to 1.25 watts per candle power, so that they represent the lowest and highest efficiency at present on the market.

Test I. on Table II. and Fig. 1 is a good example of an osram lamp. This was made by Faraday House on an ordinary commercial lighting circuit, alternating current, with a variation of voltage of about 3 per cent. each way. Twelve lamps were tested, and nine gave a life of 2000 hours, with a 20 per cent. drop in candle-power. The first failure took place at 900 hours, the other two failures following between 1200

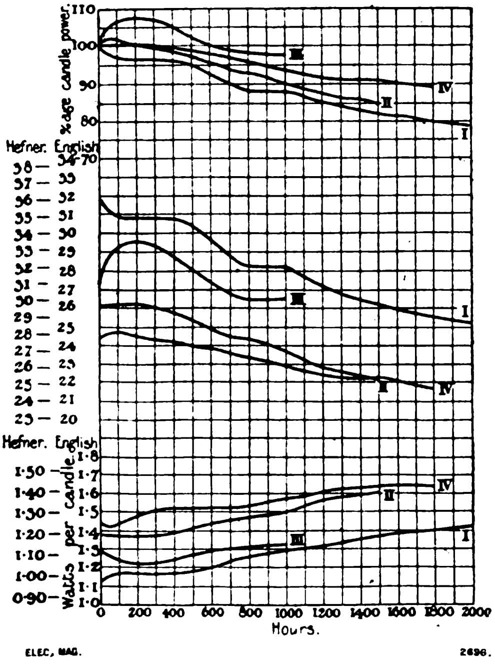


FIG. 1. AVERAGE LIFE TEST CURVES, &C., OF OSRAM LAMP.

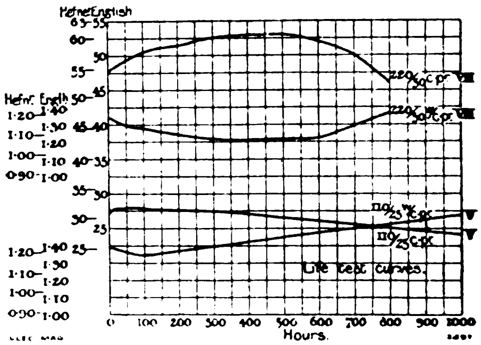


FIG. 2. CURVES OF JUST-WOLFRAM LAMP.

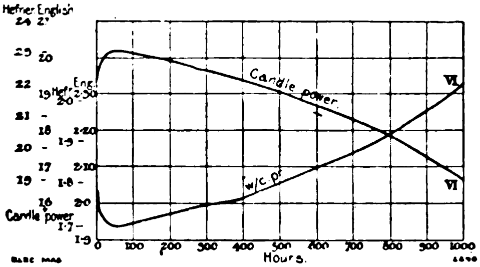


FIG. 3. CURVES OF TANTALUM LAMP.

and 1400 hours. The cost of lighting with such lamps comes out at the very low figure, including renewals, of 5¾d. per 1000 c.p.-hours.

Tests II. and IIA. on Fig. 1 are other examples of osram lamps burnt at a slightly lower efficiency, and after 1500 hours' use, the drop in candle-power only amounted to 11 per cent. This test was continued to 3350 hours, when nine lamps were still good. Their average candle-power was then 70 per cent. of the initial candle-power. It is interesting to note from this test that it pays to run these lamps to a point when the candle-power has dropped 30 per cent., as will be seen from the table.

The test No. V. on Fig. 2 of tungsten lamps made by the Just-Hanaman process shows that these lamps are quite as good as the osram.

The test was only carried to 1000 hours, but it is quite possible that the lamp could have lasted up to 2000 hours or more, with a proportionate reduction in the cost of renewals. After the 1000 hours the drop in candle-power was exceedingly small, amounting to only 3 per cent.

The tantalum tests, No. VI. on Fig. 3, give a much less favourable result than the above figures.

The test is a typical performance on a direct-current circuit. The cost per thousand candle-hours works out at 9½d., or 73 per cent. more than the osram lamp.

The carbon filament lamp results, test No. VII. on Fig. 4, were selected from a large number of tests, and represent the average English-made lamp.

A comparison of the figures in the last column of Table II. shows that the total saving from the use of osram lamps over carbon lamps when equal voltages are compared is 60 per cent.

Test No. VIII. in Table II. shows the high-voltage trials of tungsten lamps, which were made on an ordinary alternating-current lighting circuit, 50 cycles, with a voltage variation of 5 per cent., most of the variation being up. The figures show that, even paying 7s. 6d. for these 65-watt lamps, there is a saving of over 60 per cent. over the average high-voltage carbon lamp (test No. IX. on Fig. 4) when all the factors of the cost are considered.

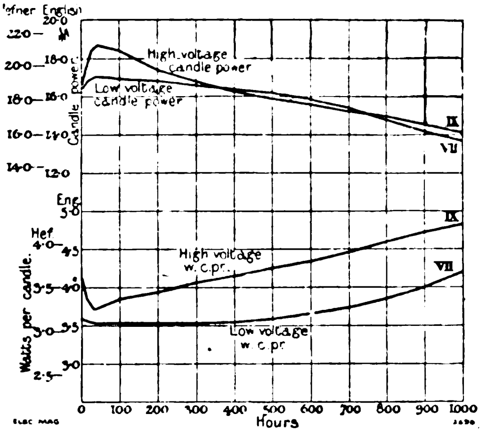


FIG. 4. CURVES OF CARBON LAMP.

In all of the above examples the price of current has been taken as 4d. per unit, which is a fair average for lighting at the present time. Of course, with higher prices per unit the saving from the use of tungsten metallic lamps is still greater.

As an instance of the life of osram lamps for public lighting, the following figures show the life of the lamps installed in the streets of Canterbury, kindly furnished by the borough engineer, Mr. C. A. Blascheck.

CANTERBURY.

Life of Osram Lamps erected in the streets, March, 1908.

ST. GEORGE'S PLACE.	LAMPS IN OPEN.	
Post No. 37 ...	1357	hours burning.
	*2434	,, ,,
Post No. 38 ...	1971	,, ,,
	2036	,, ,,
	93	,, ,,
Post No. 39 ...	*2434	,, ,,
	*2434	,, ,,
Post No. 40 ...	1779	,, ,,
	*2434	,, ,,
Post No. 41 ...	*2434	,, ,,
	*2434	,, ,,
Post No. 42 ...	1665	,, ,,
	*2434	,, ,,

Post No. 63 ...	974	hours burning.
	2	,, ,,
	*2434	,, ,,

16 lamps ... 29,349 total hours burning.

Average hours = 1834.

Dover Street and Oaten Hill.	Lanterns enclosing the Lamps.	
Post No. 179 ...	1402	hours burning.
	1500	,, ,,
Post No. 180 ...	484	,, ,,
	*2464	,, ,,
Post No. 181 ...	829	,, ,,
	*2464	,, ,,
Post No. 182 ...	*2464	,, ,,
	*2464	,, ,,
Post No. 183 ...	*2464	,, ,,
	*2464	,, ,,
Post No. 184 ...	*2464	,, ,,
	*2464	,, ,,
Post No. 185 ...	*2464	,, ,,
	*2464	,, ,,
Post No. 205 ...	*2464	,, ,,
	*2464	,, ,,
Post No. 206 ...	2315	,, ,,
	*2464	,, ,,
Post No. 207 ...	712	,, ,,
	800	,, ,,
	639	,, ,,
	1068	,, ,,
Post No. 208 ...	430	,, ,,
	736	,, ,,
	736	,, ,,
	1960	,, ,,
	1403	,, ,,
Post No. 255 ...	*2464	,, ,,
	*2464	,, ,,

29 lamps ... 51,974 total hours burning.

Average hours = 1792.

Note.—Those marked * are still burning, therefore the actual average life on completion of test will be considerably higher.

Special Applications.

25-volt Osram Lamps.—What has been said as to the likelihood that the metallic filament lamps will raise the standard of illumination, owing to the impossibility of making small candle-power lamps, applies only to those cases in which the lamps are connected on to standard supply systems at 110 volts, or two in series across 220-volt circuits.

The advantages of the pure tungsten filaments can be obtained with small candle-power lamps when a lower voltage of supply is adopted.

As an example of this, osram lamps for 25-volt circuits have been standardised for both 10c.p. and 16c.p. These lamps consume respectively 10 watts and 16 watts, and for this consumption give the same candle-power as the ordinary carbon filament lamps taking 40 watts and 60 watts. It is somewhat difficult to make use of these low-voltage lamps when only continuous current is available from the public mains. Then, in order to reduce the voltage, motor generators, double commutator balancers, or rotary converters have to be used.

While these are quite serviceable commercially when large numbers of lamps have to be supplied, the low efficiency of small sets, and the attention which the additional rotating machinery involves, will limit the extensive application in this direction.

When alternating currents are distributed the case is entirely different, as static transformers can be used which require no attention and have high efficiency. The low voltage required for these small candle-power lamps can then be obtained at a cost which brings them into effective competition with the incandescent gas mantle for private-house lighting.

The opinion has often been expressed, and is still held by many, that the cost of the transformer, together with the losses in the same, would more than nullify the saving from the use of metallic filament lamps. The iron loss in such transformers is constant, and goes on whether the lights are burning or not. Hence, to get the best result, these transformers, like those still largely used for reducing high pressure to say 220 volts for house lighting, must be designed with a minimum of iron loss so as to obtain a high all-day efficiency.

For use with these lamps special transformers have been constructed on the above lines, from which the following figures have been obtained on test:—

The iron loss on the transformer designed for 300 watts output is as low as 5 watts

The following figures (Table III.) show the units taken per year by this and two other transformers of a larger size to overcome iron losses:—

TABLE IV.

Annual Costs for Current on an Installation of 25 16*c.p. Lamps, of which* 19 *are Burning at one Time.*

(16-watt Osram Lamp *v.* 60-watt Carbon Lamp.)

No. of Hours per Annum at Maximum Load.	Maximum Load in Watts.		Units used per Annum with Osram Lamps.			Units used for Carbon Lamps.	Cost of Current at 4d. per Unit.		
	Osram Lamps.	Carbon Lamps.	Osram Lamps.	Trans-former.	Total.		Osram Lamps.	Carbon Lamps.	Saving.
							£ s. d.	£ s. d.	£ s. d.
300	304	1140	91	44	135	342	2 5 0	5 14 0	3 9 0
400	304	1140	122	44	166	456	2 15 3	7 12 0	4 16 9
500	304	1140	152	44	196	570	3 5 3	9 10 0	6 4 9
600	304	1140	182	44	226	684	3 15 3	11 8 0	7 12 9
700	304	1140	213	44	257	798	4 6 6	13 8 0	9 1 6
800	304	1140	243	44	287	812	4 15 6	15 4 0	10 8 6

TABLE III.

Details of Iron Losses of Small Transformers.

Output of Transformer in Watts.	Number of 16c.p. Osram Lamps Alight at one time.	No Load.	Iron Losses.	Units Taken per Year.	Cost per Year at 4d. per Unit.
		Watts.	Per-centage.		£ s. d.
300	19	5	1.67	44	0 14 8
750	47	10	1.33	88	1 9 4
1500	94	17	1.13	149	2 9 8

The cost per year at 4d. per unit is given in the last column.

The copper losses in these transformers are not large, and only occur when the lamps are being used. The total loss in the copper of the transformer, and in the wires between the transformer and the lamps, will not be appreciably higher than the copper losses in the cables alone when carbon lamps are used.

Table IV. at the top of this page shows the financial results from the use of these 25-volt 16c.p. osram lamps in a private house requiring twenty-five lamps. It is assumed that the smallest size of transformer in the preceding table will suffice, as nineteen lamps alight at one time is about the extreme maximum load in such a house. The total saving in current shown in the last column varies with the number of hours the lamps are in use; at 500 hours' use the saving in current is £6 4s. 9d. on a yearly bill of £9 10s. when carbon lamps are used. The current account is thus reduced 65 per cent., but the bill for lamp renewals will be somewhat higher.

Table V., below, shows the complete balance sheet obtained by adding the cost of current to the lamp renewal charges for both carbon and osram lamps.

These tables clearly indicate that private houses in those areas over which electricity is distributed in the form of alternating current can at once realize to the full the exceptional radiating properties of the tungsten filament.

As some engineers may object to the statement above as to the copper losses of the transformer being small, the formula below will enable them to calculate what the comparative cost of osram and carbon lamps would be if these copper losses are also taken into account.

TABLE V.

No. of Hours per Annum of Maximum Load.	Osram Lamps.		Carbon Lamps.		Total.		Total Saving with Osram.	
	Current.	Lamp Renewals.	Current.	Lamp Renewals.	Osram Lamps.	Carbon Lamps.		
	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	%
300	2 5 0	1 10 0	5 14 0	7 1	3 15 0	6 1 1	2 6 1	38
400	2 15 3	2 0 0	7 12 0	9 6	4 15 3	8 1 6	3 6 3	41
500	3 5 3	2 10 0	9 10 0	11 10	5 15 3	10 1 10	4 6 7	43
600	3 15 3	3 0 0	11 8 0	13 3	6 15 3	12 1 3	5 6 0	44
700	4 5 6	3 10 0	13 6 0	16 7	7 15 6	12 2 7	6 7 1	45
800	4 15 6	4 0 0	15 4 0	19 0	8 15 6	16 3 0	7 7 6	45½

a = Open circuit loss in watts.
b = Number of lamps.
c = Candle-power.
d = Cost per unit.
e = Average hours of running per year.
f = Copper loss on average load.

The cost of lighting with osram lamps per year works out at—

$$8.76\,ad + \frac{bced}{1000} + \frac{fed}{1000}$$

The yearly cost of lighting with carbon lamps as against this works out to be—

$$3.5\,\frac{bced}{1000}$$

This under the assumption of an efficiency of 1 watt per Hefner candle for the osram lamp and 3.5 watts for the carbon lamp.

The saving in running cost is per year—

$$3.5\,\frac{bced}{1000} - 8.76\,ad - \frac{bced}{1000} - \frac{fed}{1000}$$

$$= d\left(\frac{2.5\,bce - fe}{1000} - 8.76\,a\right)$$

If we take the cost of an actual installation as an example, and figure on 25 16c.p. lamps (b equal to 25, c equal to 16) and take from actual measure—

a ... ... = 5
f (to be on the safe side the maximum copper loss has been taken, not the average) ... ... = 12
d ... ... = 4d.
e ... ... = 1000

Under these conditions the saving works out, as per above formula, to £15 14s. 9d. on a total of £23 6s. 8d., equivalent to a saving of 67.4 per cent.

If we had not transformed down, but taken the smallest obtainable candle-power, namely 28-watt osrams (against 16c.p. carbon lamps), the saving would have been £11 13s. 4d., equal to 50 per cent.

If we take further into consideration the cost of renewals and the additional cost of the transformer, we find :—

	£	s.	d.
First cost of transformer ...	2	2	0
Amounting to an annual outlay (reckoning on five years' amortisation) about	0	9	0
Cost of renewals for osram lamps 25 × 3s.	3	15	0
Cost of renewals for carbon lamps 25 × 1s. 3d. ...	1	11	3
Difference ...	2	3	9

The actual saving is therefore £15 14s. 9d. minus £2 12s. 9d. = £13 2s., which is equivalent to 56.2 per cent.

The no-load losses have decreased the original saving in running cost by 4.5 per cent.; the copper losses by 1 per cent. (therefore from 67.4 to 62 per cent.)

An unexpected objection has arisen to the use of these small transformers from certain central-station engineers—they find that the iron losses are so small that they will not keep the meter running. If this is the case, these iron losses, which should be borne by the consumer, fall on the station—which is obviously incorrect.

With the high-pressure distribution, using transformers in consumers' houses, which was common practice ten years ago, the electricity meters were always placed on the low-tension side of the transformer, and the price per unit was fixed with due consideration of this fact. The author would suggest, therefore, that those supply engineers who wish to make use of osram lamps to extend their private-house load should themselves supply these small transformers and charge the consumers a slight increase per unit to cover the iron losses, and also the capital expenditure involved.

There is another large field for these low-voltage lamps in connection with isolated plants for the supply of country houses, workshops, &c. Where small units of light are quite sufficient the cost of the generating plant can be reduced very largely as the output required falls in the ratio of the efficiency of the filaments used in the lamps. Thus the maximum load in any given case falls in the ratio of 3½ to 1, and neither the factory inspector from the Home Office nor the fire insurance company claims that supply at 25 volts is dangerous.

The same reduction in the cost of generating plant in mains can be realised when designing electric lighting equipment for the numerous small towns and villages within the United Kingdom yet to be supplied with electrical energy. In such undertakings the capital burden to be borne by the relatively few consumers obtainable is the chief deterrent.

ELECTRIC CRANES IN IRON AND STEEL WORKS.

THE several illustrations give typical examples of the work of Messrs. Appleby's, Ltd., in the way of electric cranes for special services in various iron and steel works. The overhead travelling revolving jib crane shown in Fig. 1 is of 2 tons capacity. It works over a radius of 10ft. from centre of post to hook, and runs on rails spaced 20ft. apart, centre to centre. Its four motions of lifting, slewing, travelling, and traversing, are each worked by a separate electric motor. The lifting is actuated through a worm reduction and one set of spur gears. The worm is of steel, working in a phosphor-bronze worm wheel, and fitted with ball-thrust bearings. The second motion is machine cut, having wrought steel pinion and cast-iron spur wheel. The lifting barrel is of the ordinary grooved type, and the speed of lifting about 15ft. per minute with full load. The slewing motion has a speed of 180ft. per minute with full load, and is motor driven through worm, bevel, and spur gears. The travelling gear consists of two reductions of spur gearing, the speed of travel being 150ft. per minute. The traversing motion is actuated by motor through worm reduction gear, the power being transmitted to the driving wheel of the crane by means of spur and bevel gears. The speed of traversing is 60ft. per minute. The motors of this crane are of the series-wound enclosed ventilated type, their powers being: lifting, 3b.h.p.; travelling, 3b.h.p.; traversing, 1½b.h.p.; slewing, 1½b.h.p. The larger motors run at a full-load speed of 1080r.p.m., the smaller at 540r.p.m. The controllers are all of the tramway type, arranged alongside each other in the driver's cage. A modified form of this crane is in use at the Parkhead Works, Glasgow.

The illustration Fig. 2 represents a

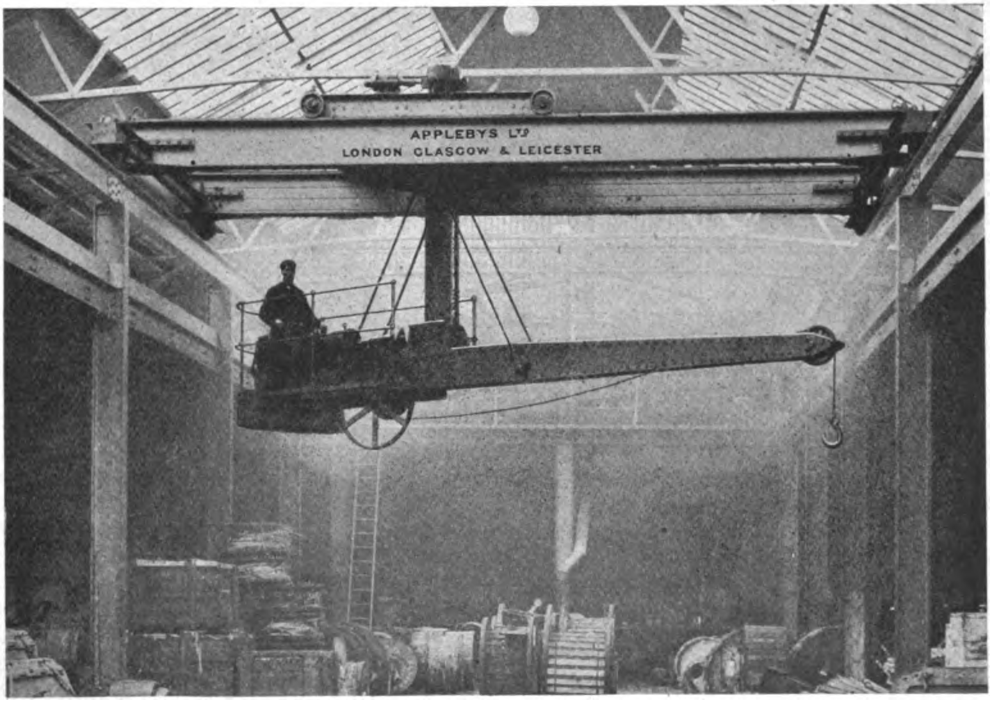


FIG. 1. TWO-TON OVERHEAD TRAVELLING JIB CRANE.

specially constructed five-motor electric crane, one of a number of 4-ton cranes supplied to charge and to discharge soaking pits at a large steel works in Sheffield. The headroom available for these cranes is only 13ft. 6in. measured from the rail; this restriction, together with the high speeds required and the total height of lift (eleven feet above rail) necessitated the very special design illustrated. The jib is horizontal, and is fitted with a traversing trolley which enables the effective radius of the crane to be varied from 8ft. minimum to 22ft. maximum, at which latter radius the crane will lift 3 tons free on track. The travelling motion is driven by two motors, one being coupled to each axle. A powerful automatic electric brake is fitted to one axle, and buffing beams and draw gear are arranged to suit the steel works' rolling stock. The lifting gear is fitted with a large motor, gearing with single and double purchase to the hoisting drum. An efficient electric brake is fitted to the spindle of this motor. The crane has a complete slewing motion driven by a separate motor, and the derricking is also accomplished by a separate electric motor. All the motors are series-wound and reversing, and are regulated with patent liquid controllers. The controllers are arranged in the front of the crane where the driver has a complete view of his load in all positions. A specially designed trolley pole is fitted to accommodate the extremely low headroom, and also to suit a greater elevation of trolley wire in the open yard.

On the following page is shown, Fig. 3, a special 100-ton ladle crane which has recently been installed at the works of Messrs. Vickers, Sons & Maxim, Ltd. The crane consists of a pair of parallel girders with a heavy crab running between the girders. The arrangement is such that in the case of the heavy crab, the lifting ropes descend from a pair of barrels on both outer sides of the main girders, whilst in the case of the light crab, the lifting ropes descend from a single barrel between the two girders, thus the one crab can pass the other crab in any position that either may occupy on the main girders, provided only that the lifting blocks of the heavy crab are sufficiently low, and that of

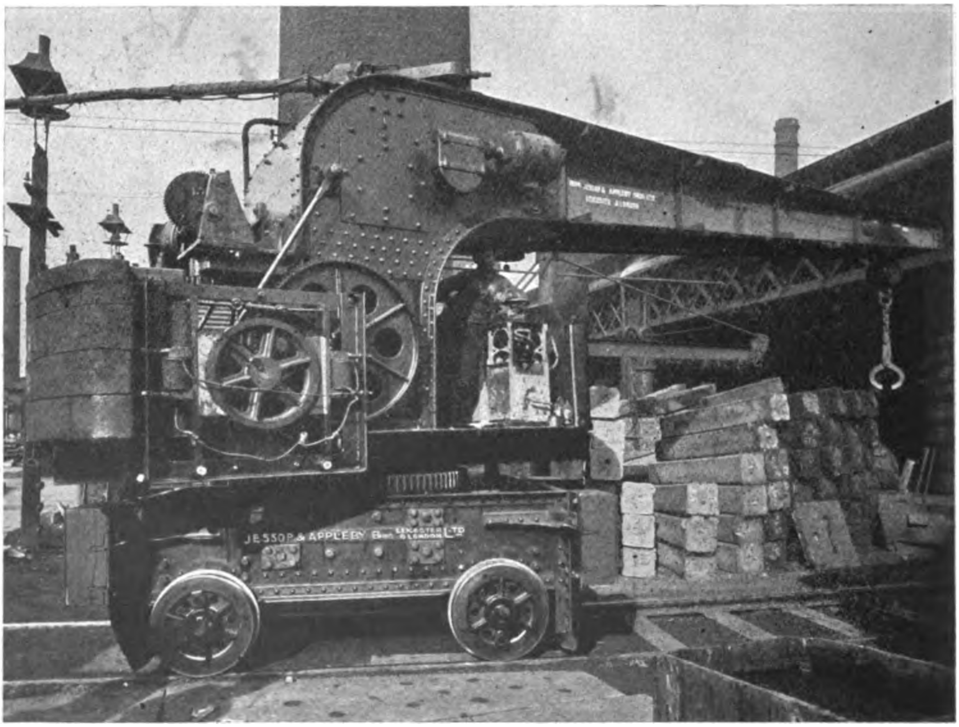


Fig. 2. Four-ton, Five-motor Electric Crane.

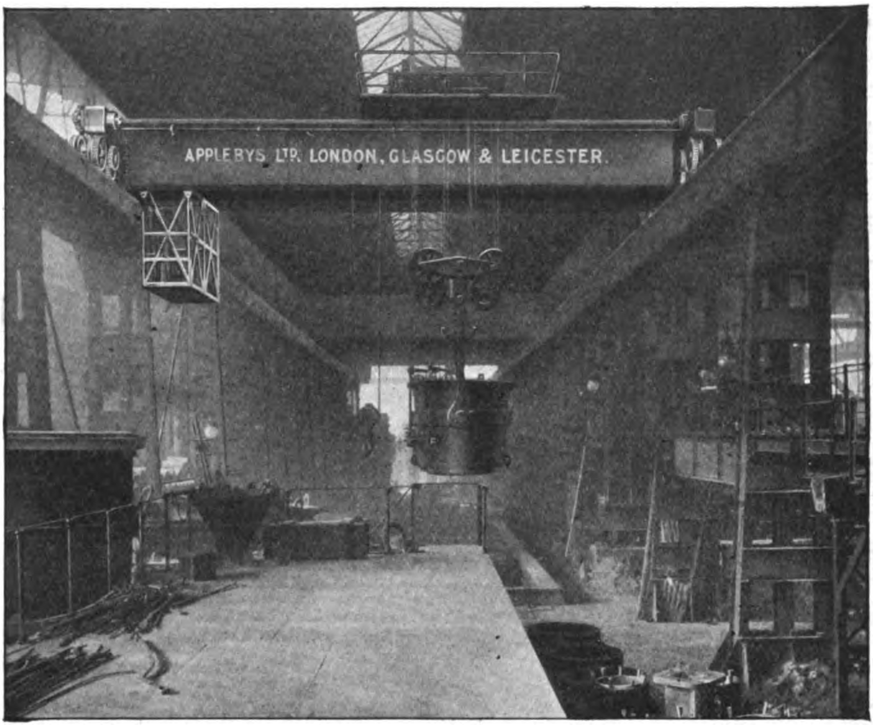


FIG. 3. A 100-TON LADLE ELECTRIC CRANE.

the light crab sufficiently high. The crane which lifts a working load of 100 tons on the heavy crab, and simultaneously, if desired, a working load of 25 tons on the light crab, runs on two pairs of rails distanced 46ft. from the centre of one pair to the centre of the other pair. The crane has five motions, each operated by a separate motor either independently of one another or simultaneously, namely: lifting and lowering heavy crab, traversing heavy crab, lifting and lowering light crab, traversing light crab, and travelling the complete crane. The motors are of the enclosed ventilated standard crane type, the controllers and resistances are "Stellite" standard crane type. The heavy crab runs on eight traverse wheels, four geared and four ungeared, whilst the light crab operates on four traverse wheels, two geared and two ungeared. The travelling gear consists of eight pairs of double-flanged steel travelling wheels with machined treads, four pairs geared and four ungeared. Powerful electro-magnetic and mechanical brakes are fitted to both crabs, giving perfect control of the load and safety in operation. The weight of the crane complete is about 100 tons.

Another ladle crane exhibiting features of particular interest was one designed and built by Messrs. Appleby's, Ltd., for service in a large steel works in Yorkshire, and which is complete with all latest improvements for performing somewhat complicated operations under the most favourable conditions as regards safety, economy in time and cost of labour with absolute control throughout each operation. The work performed consists of conveying the ladle containing molten meltal from the furnaces to the ingot moulds, the total weight being about 65 tons, and pouring the molten steel into the moulds which are arranged in line along one side of the casting house.

In order to effect these operations with ease and certainty, the crane is equipped with two crabs, one of 80 tons power for conveying the metal to the ingot moulds, and an auxiliary crab of 10 tons power which tilts the ladle for pouring slag and for other purposes. The 80-ton crab, which traverses from end to end of the main beams, is provided with lifting chains built of high tensile steel plates and steel con-

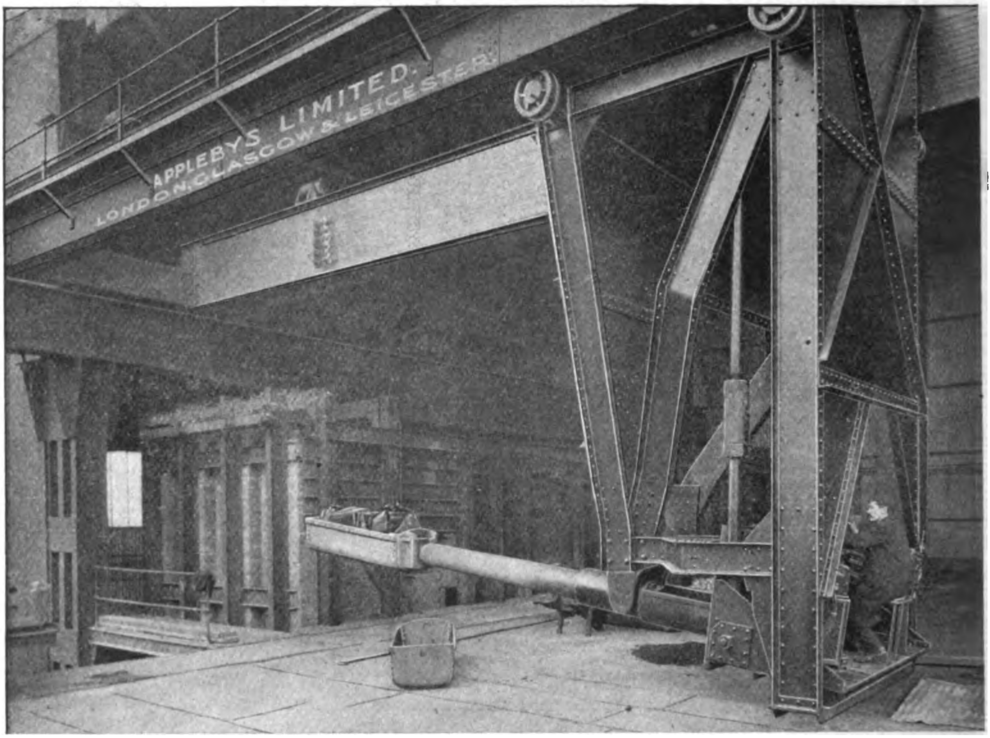


FIG. 4. THREE-TON OPEN HEARTH ELECTRIC CHARGING MACHINE.

necting pins. Both of the crabs have motors respectively for lifting and cross traverse, the motor for travelling longitudinally being fixed centrally on one of the main beams.

The motors are series-wound of the enclosed reversing type, suitable for direct current of 220 volts, and vary in power from 100h.p. for the main hoist to 5h.p. for the auxiliary traverse.

The machine illustrated in Fig. 4 was constructed under the Wellman-Seaver-Morgan patents, by Messrs. Appleby's, Ltd., and is, in effect, an electrical overhead travelling crane with four electric motors and appliances which can be used separately or in combination for taking boxes containing scrap steel and other material from bogies on the charging platform level, and delivering the contents into the furnace. The machine travels above a line of rails which carry the bogies along the front of the furnace doors, and after emptying the boxes replaces these on the bogie; it then draws up another loaded bogie and shunts the empty one, all operations being completely controlled from the driver's platform where the switches and controllers are fixed.

The machine is provided with a separate motor for each of its four operations, viz., travelling longitudinally, cross traverse, lifting the boxes, tilting them and restoring them to the bogie when empty. The last-named motions are operated from a strong steel frame which is attached to an overhead traversing trolley, and carries the changing arm with rectangular steel head. This head fits into the end of the steel charging box, and the arm is pivoted on the hanging frame, so that it may be tilted by the heavy steel rods at its back which are in connection with the tilting motor fixed on the trolley frame and controlled by the driver.

The charging arm is advanced by traversing the trolley, and the end of the bar is elevated sufficiently to drop into the socket at the end of the charging box. A central locking rod is then pushed forward through the charging arm, thus securely fixing it on the charging box. The tilting motion is then brought into operation and the box elevated, the contents being delivered into the furnace by partially turning the charging arm. The reversal of these motions brings the empty box back to the trolley for refilling.

MANUFACTURING Progress

"The Lancaster" Steam Trap.

THE specialities of Messrs. Lancaster & Tonge, Ltd., are known to every steam-power engineer, and this is particularly true of the steam traps, of which some 80,000 are said to have been sold during the past twenty-five years. Following the requirements of modern practice the makers have recently introduced a new form of steam trap in which the best features of the former design of trap have been retained, whilst there has been gained a greater compactness and strength, together with other advantages. Though it has been but a comparatively short time on the market, it has met with striking success and many thousands have already been sold. It is being largely used by the Government, also by most of the leading engineers and manufacturers of this country and abroad, a large number of whom have been users for many years of the old style of "The Lancaster" trap, who have readily appreciated the improvements in the new type.

The general principles and arrangement of the new trap will be seen from the illustrations, Figs. 1, 2 and 3. The float is cylindrical and extends the full length of the box, enabling a greater capacity in a smaller box than did the old style fitted with its ball float. The new type is consequently very small for its capacity, a ⅜in. trap being 9in. high, 10in. long, and 6in. wide.

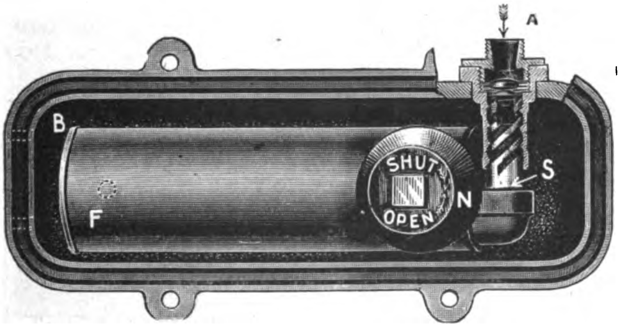


FIG. 1. SECTIONAL PLAN OF STEAM TRAP.

The most important feature of the trap is the loose disc valve at the orifice of the discharge pipe in connection with a quick thread screw motion, worked by the float. The valve is frictionless in action, and, being loose, cannot stick to its seat. It is very prompt in its movements for opening and closing the discharge pipe, and the working parts are very simple and easily examined, as it works equally well with a loose lid. It also acts as a safety valve, since any excessive pressure exerted against the face of the loose disc valve would, by virtue of the quickness of the screw thread, force it open.

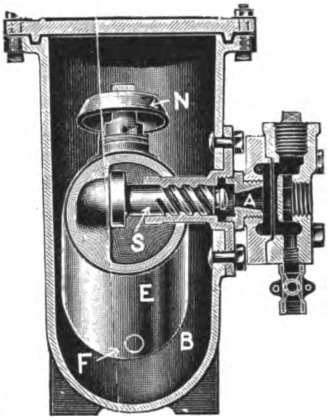


FIG. 2. END SECTION OF STEAM TRAP.

As illustrated, the copper float E, having a hole F in the

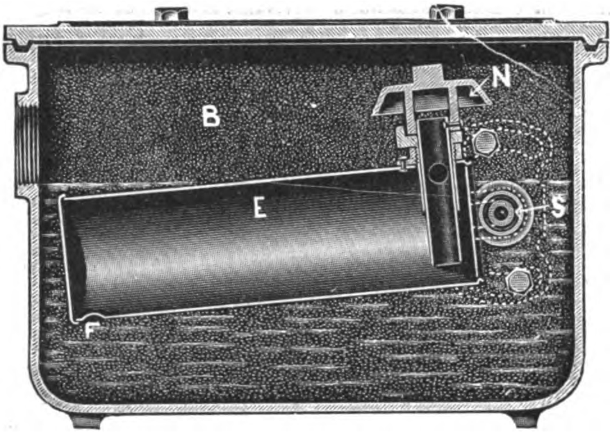


FIG. 3. SIDE SECTION OF STEAM TRAP.

bottom and a tubular valve N on the top, is connected to a screwed spindle S at the end of which is a loose valve, which is alternately opened and shut by the falling and rising of the float rotating the screwed spindle.

The normal position of the trap is with the float at the bottom of the box and the valve full open. As the water to be drained passes through the hollow spindle into the float, the latter is water logged and stays at the bottom till all is discharged, when the steam following enters the float, drives out the water through the tubular valve N, and the float, becoming buoyant, rises and closes the valve.

As the steam left in the float condenses, water from the box flows into it, until it falls again and opens the valve, when the same action ensues. So long as the steam or water flows to the trap it continues to work as above described even if only one pint per hour of condensed water is discharged, unless the rate of condensation is extremely steady, in which case the float tends to set itself in such a position as to discharge the water in a steady stream.

The adjustable air valve N, fitted to the top of the float, entirely overcomes the trouble due to the re-evaporation of water at high temperatures, and water at any temperature up to that of the steam from which it is drained can be effectually cleared from the pipes or vessel to be drained by opening it as required.

To prevent dirt entering the trap the makers have designed and patented a union and sieve combined. The union is of the ordinary flanged type, with a chamber, in the centre and is made of cast iron. The joint between the two halves is made by a circular sheet of copper gauze which effectually prevents everything coarser than the finest mud passing to the trap. A plug tap is fitted on the bottom side of the union to drain away the dirt which collects in the chamber in the centre of the union and should be opened for this purpose occasionally. An alternative inlet is made in the edge of the union, and by twisting one half of the union round on the other, the inlet may be arranged vertically or parallel with the outlet in either direction.

The particular merits claimed for this trap are its compactness, strength, and accessibility. As to its reliability the makers point out that many hundreds of "Lancaster" traps are still at work after twenty years' efficient service.

At the end of a very complete catalogue recently issued by the firm is shown an engine, the cylinders of which are drained by the traps in such a manner that the rate of condensation can be ascertained at any time.

This arrangement will be of particular advantage to those who are troubled with wet steam, as it enables them to ascertain the amount of water in the steam at any time.

These traps have worked for four years with great success.

The "Lancaster" steam trap has been fitted to many of the largest and swiftest liners, including the *Lusitania* and the *Mauretania*. The makers lay considerable emphasis on this fact, and this would appear justifiable, as it will be remembered that the vessels named were built in different establishments.

It is of interest to power engineers to note that Messrs. Lancaster & Tonge advertise that they are prepared to supply these traps to new customers for three months' trial on approval.

MANUFACTURERS ARE INVITED

to supply particulars of New and Interesting Machinery and Appliances for inclusion in the "Manufacturing Progress" Section of

The ELECTRICAL MAGAZINE.

Small Motor Manufacture.

THERE is probably no firm which has been more closely associated with the development of electric machinery than the Maschinenfabrik Oerlikon. The Oerlikon works at Zurich were founded in 1872 and were originally engaged in the manufacture of wood-working and general machine tools, for which they enjoyed a high reputation. With the introduction of applied electricity the proprietors turned their attention to the production of electrical plant, and in this were pioneers, quickly earning recognition in all parts of the world by virtue of the valuable original lines which they throughout adopted.

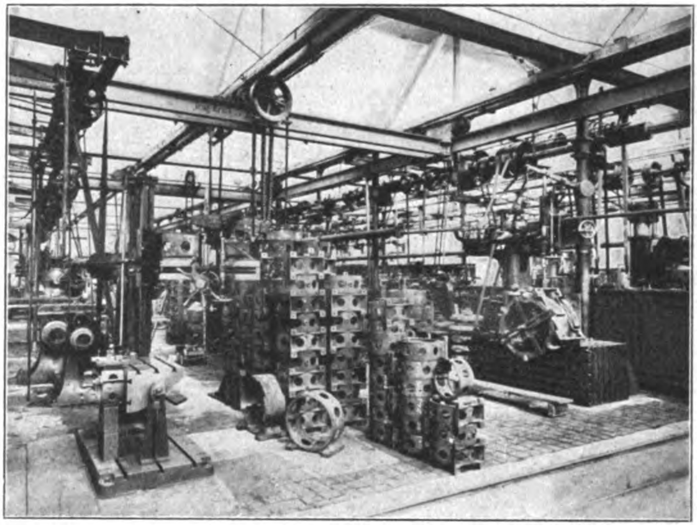


Fig. 1. Machining Motor Frames.

Since those early days of the electrical industry the Oerlikon Company has ever advanced and can well claim to have retained a position in the forefront of electrical manufacture. In this country they have always been known to central-station men, their work in connection with the early single-phase public supply systems establishing them once and for all in the British market. The British, Irish and Colonial Department of the Maschinenfabrik Oerlikon is in charge of Mr. G. Wuthrich, whose offices are in Oswaldestre House, Norfolk Street, London.

The latest noteworthy development of the Company is the organizing of a separate works for the rapid manufacture of small motors. The Zurich site had been filled step by step until, when the construction of steam-turbines and turbo-generators was undertaken, no available space remained. The ever-increasing demand for small motors compelled the Company to take drastic measures and it was eventually decided, in 1906, to discontinue the manufacture of machine tools and to rearrange the works so that the old machine-tool department should be entirely rearranged for the

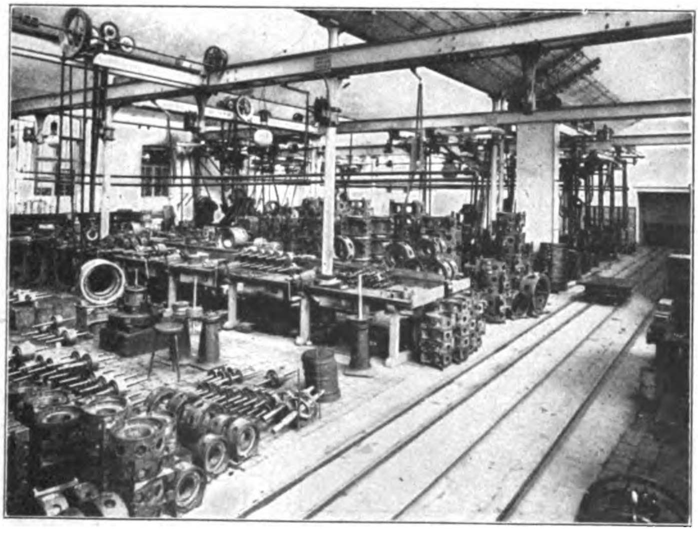


Fig. 2. Core Building and Stamping.

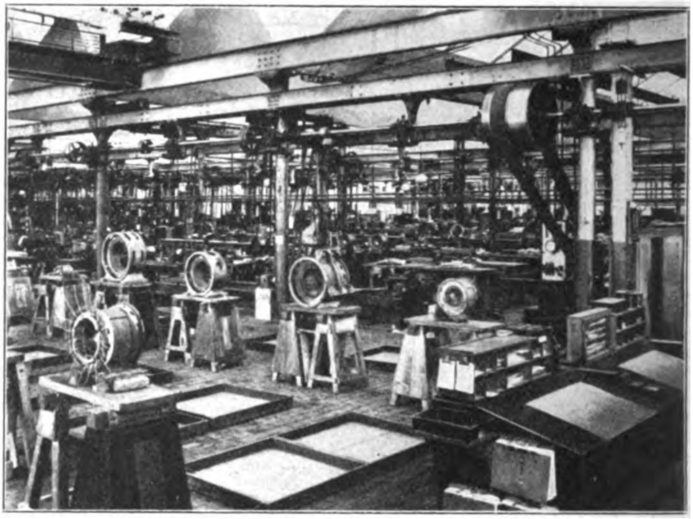


FIG. 3. WINDING DEPARTMENT.

manufacture of small motors and cranes, and the original crane department taken over for the needed extension of the steam-turbine department.

The new small motor section has been so arranged in its departments and tools that the work of manufacture progresses easily with the minimum handling of parts and consequent saving of time and labour. The main shop is divided into three parallel bays or aisles, in one of which are effected all the machining of carcases, end-bells, shafts, &c. In connection with this part of the work it is to be noted that many special machine tools are employed, these being designed so that the various faces of any part can be worked up simultaneously with one setting of the piece and ensuring absolute duplication.

The second aisle is devoted to the finishing of smaller parts such as commutators, collecting-rings, brush gear, terminals, &c., also to the machining of pulleys and slide-rails. The third branch of the works accommodates the core stamping and notching machines, which are used exclusively for producing discs, &c., for the small motors. These three sections converge to a centre shop where the main parts are assembled and from which the armatures, rotors and stators pass into the winding shops. Thence the machines pass through the final assembling shop, test department, and into a separate store where they are systematically arranged and a constant supply is kept available for immediate delivery.

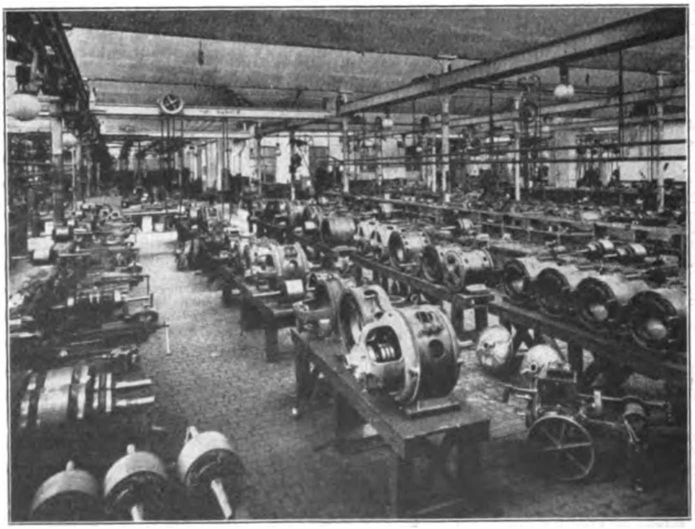


FIG. 4. ASSEMBLING DEPARTMENT.

The small motor section of the Oerlikon products includes direct-current and alternate-current machines up to the 60h.p. sizes. The latter are built in both the slip-ring and non-slip-ring types, and are also built in numerous standard sizes, as for constant-speed or variable-speed working. It is noteworthy that the alternate-current machines are not built in one type which the makers would endeavour to sell for all and every purpose; thus the makers stock motors for auto-starters in primary, resistance starters and short-circuiting devices in secondary; pole-changing starters and controllers, &c., &c., so that whether the requirements be for such diverse purposes as pumping service in mines, or for cranes, the best machine for the intended work can be supplied in all cases.

Tests of "Liconite" Cables.

THE following are details of tests which were made on "Liconite" cables at the works of Messrs. Johnson & Phillips on May 26th. Some general particulars regarding this new material, which is proposed as a cheap and effective substitute for rubber and gutta-percha, are given on page 377.

Test 1. Leadless paper cable immersed in water wherein it had lain for twelve days was flashed with 30,000 volts for 5mins., and showed no signs of breakdown. Length of cable, 200 yards; size, 0.25 square inches copper, insulated with fifty-six layers of Liconite-impregnated paper to a thickness of ⅜in. and covered with two layers of "Liconite" tape, and one layer of Hessian tape; insulation resistance tested May 23, 1908, 10.3 megohms per mile.

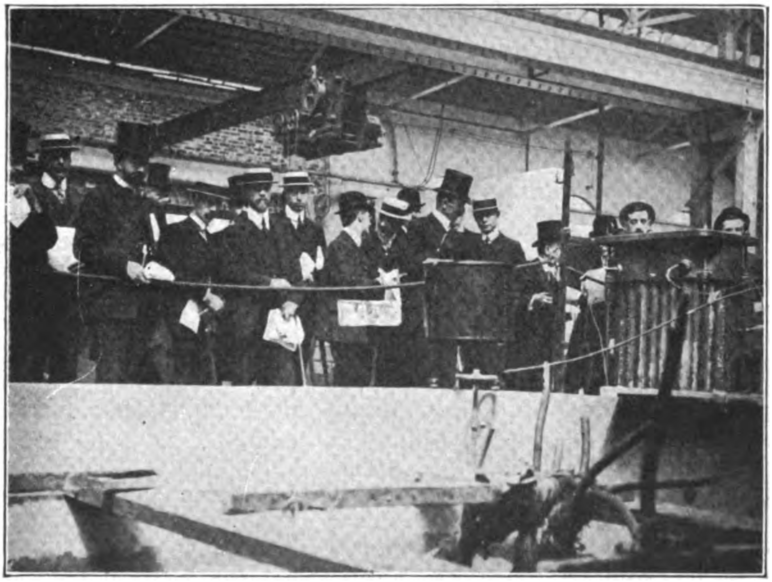
Test 2. A two-yard length having been cut off the above cable and bent round a drum 18in. in diameter three times in each direction, was then flashed at increasing pressures until it reached the limit of the testing transformers at about 70,000 volts, at which the sample did not break down.

Test 3. A two-yard length of the same cable which had been immersed with its ends bare and under water for seven days, and which before being immersed was bent round a drum 18in. in diameter three times each way, was flashed at increasing pressures up to 70,000 volts. It withstood 70,000 volts for some two minutes, but broke down eventually at 52,000 volts as the pressure was being gradually reduced.

Test 5. A three-phase "Liconite" elastic cable, having no paper or tape in the dielectric, was flashed up to 50,000 volts between each pair of cores; the pressure in each case was maintained for seven minutes, the cable showing no sign of breakdown. Length of cable, 200 yards; size of each core, 19/.085 aluminium covered with thin layer of lead to a diameter of .55in., the whole equivalent to .07 square inches of copper; thickness of insulation, ½in.; lay of cable, 40in.; outside diameter of the three cores laid up, 3½in.

Test 6. Cable insulated with "Liconite" elastic and tape (known as reinforced "Liconite" cable) was tested up to 30,000 volts for five minutes and showed no breakdown. Length of cable, 40 yards; size, 0.25 square inch copper, insulated with six layers of "Liconite" elastic, upon each of which layers is wrapped one of "Liconite" tape to a thickness of ½in, the cable being then braided; insulation resistance tested May 23, 1908, 86 megohms per mile.

Test 7. A two-yard length cut off the cable



AT THE "LICONITE" CABLE TESTS, MAY 26TH, 1908.

of Test 6 was bent round a drum 18in. in diameter, three times in each direction, and was then flashed at increasing pressure until it finally broke down at 54,000 volts.

Other tests were to have been made on "Liconite"-impregnated paper sheets similar in character to the paper tape wrapped on to the above-mentioned paper cable, being flashed until breakdown. Unfortunately the test transformer would not permit of sufficiently low pressures being used, all the samples breaking down instantly at about 20,000 volts.

"Liconite" elastic sheets tested in a similar manner showed that a sheet of 62mils. thickness broke down at 31,000 volts; 108mils. at 42,000 volts; other sheets above this thickness flashed over the surface at 63,000 volts without breaking down.

The above tests serve to indicate that "Liconite" promises well as an insulator, the outstanding feature being its remarkable water-resisting property. It is too early yet to venture an absolute opinion as to its final value for cable work, but with the results already obtained and the remarkable cheapness of the material a good start has been made and it will pay cable makers and users to give "Liconite" every consideration. Full information on the subject can be obtained from Messrs. Wm. Geipel & Co., Vulcan Works, St. Thomas Street, London, E.C.

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"Freezor" Electric Fans.

The General Electric Company make quite a large range of small fans for both direct current and alternating current work. These have one and all been put upon the market under the trade name of "Freezor." Probably the one which meets with the largest demand is the "Universal" type, which has been specially designed to conform with the Admiralty specification. The entire insulation of the armature and field windings of the motors is of the highest grade, and the regulating resistance, by which three ranges of speed are secured, is mounted on a special porcelain base fixed inside the foot or pedestal of the fan. The insulating materials used throughout are mica and presspan, and all fans are tested to withstand a pressure of 500 volts alternating current between windings and frame, the insulation resistance being not less than 2 megohms. These are stringent tests for small machines of this type, and would appear to mark the machines as particularly to be depended upon for reliable service in hot, damp climates. The standard size of the "Universal" fan has blades 12in. in diameter, and it is supplied for continuous currents of 100 up to 250 volts. The similar fan for alternating currents has 12in. diameter blades, and is supplied for 100 to 200 volt circuits, 50 to 100 periods.

For small offices, shops, and domestic purposes a "Freezor" fan having 9in. diameter blades is also made.

The General Electric Company manufacture a range of slow-speed ceiling fans which are preferred by many for cooling larger sized rooms, halls, &c. These fans run at comparatively low speeds and are fitted with either wood or aluminium blades having a 56in. sweep. A smaller cabin-type of ceiling fan is supplied for low rooms. It consists of a desk fan body fitted with a tripod for attaching to the ceiling, and has a pair of aluminium blades having either 26in. or 36in. sweep.

For the ventilation of large public rooms, works buildings, industrial factories, &c., the porthole type of fan is almost exclusively used. The "Freezor" fans have been adapted to this service, and are standardised in many sizes. Thus the direct-current types, fitted with either open or enclosed type motors, can be obtained in six sizes, ranging from 12in. diameter up to 42in. diameter, the former having a capacity of 1100 cubic feet per minute, and requiring 60 watts for its operation, the latter moving 14,500 cubic feet of air per minute, and requiring 475 watts for its run. In the alternating-current types the sizes standardised range from 12in. diameter up to 36in., having capacities of 1300 and 10,000 cubic feet of air per minute respectively.

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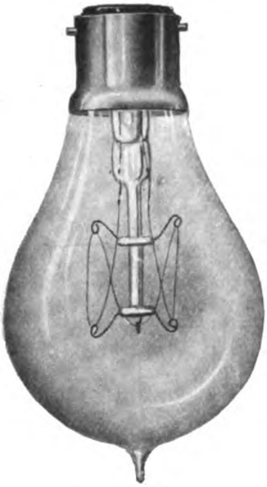
Tantalum Lamps for Street and Train.

The tantalum lamp has lately come into very considerable demand for street lighting usage. One of the most extensive installations of this character is at Brighton, where the tantalum lamp has been adopted



TANTALUM LAMP.

to replace the older-type carbon filament glow lamps for the public lighting of side streets. A recent order of the Corporation to Messrs. Siemens Brothers Dynamo Works, Limited, covered no less than 15,000 tantalum lamps for this purpose, preliminary trials having demonstrated the entire suitability of this Company's new lamp for public street-lighting, a class of service which would appear to have been somewhat neglected, but which bids fair now to offer quite a considerable market for the earliest and most established form of metallic filament lamp.

A further noteworthy feature of the extending vogue of the tantalum lamp is its introduction for the lighting of railway carriages. Messrs. Siemens have recently fitted out two trains of the London Underground Electric Railways' system, and it is reported that the results of this preliminary work have shown the new lamp to be satisfactory in every way for this exacting work.

* * *

"Stellite" Electric Fans.

THE "Stellite" electric fans as manufactured by the Electric & Ordnance Accessories Company, Ltd., Birmingham, exhibit many features of design which will commend themselves to those who are on the lookout for a compact and convenient means of securing ventilation and coolness. Each fan combines in itself the distinctive features of the desk, trunnion and bracket types, so that the one type is equally suitable for use on table, floor, wall or ceiling, and the fan can be rapidly adjusted to direct the current of air as required.

The frame consists of a handsome pedestal of soft grey cast-iron, with a gimbal ring of the same material. The pedestal is fitted with rubber feet to absorb vibration and prevent damage to polished surfaces. The gimbal has brass fittings. The field cores are cast in one piece with the motor body, thus forming an unbroken magnetic circuit. The commutator is of hard-drawn copper, and the slots of the armature are carefully lined with insulating material. Double silk-covered high-conductivity copper wire is used for the armature and field windings, and before and after taping all coils are impregnated under vacuum pressure with an insulating compound, rendering them impervious to moisture, and ensuring perfect insulation. The carbon brushes are self-regulating, and the armature bearings, of phosphor bronze, are fitted with wick-feed lubricators.

The starting switch and speed regulator are fitted inside the base, the resistance consisting of wire coils wound on non-hygroscopic porcelain. Spring catches ensure the switch being left central on the respective stops.

The standard finish is black enamelled frame and body, polished brass fittings and guard, and polished brass blades. Fans can, however, be supplied with the brass work nickel plated, and frame finished in white and gold or other colours as desired.

The 12in. fan is the most popular size made, and is adapted for offices, small stores, counters, and similar places where a strong breeze is desired. It is a light-weight portable fan, consuming very little power,

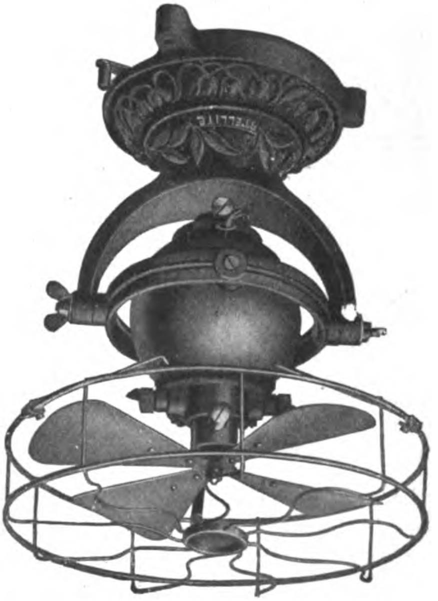


FIG. 1. "STELLITE" CEILING FAN.

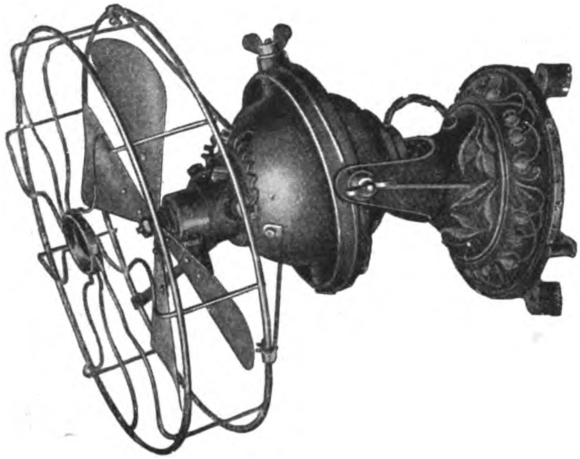


Fig. 2. "Stellite" Bracket Fan.

and is guaranteed to operate continuously for long periods without overheating.

The 16in. fan throws a very strong blast of air to a considerable distance, and is especially suitable for use in large rooms, stores, restaurants, saloons, and wherever the maximum breeze is required. It is a very compact motor, but develops a strong torque, and throws an excellent current of air.

In addition to the type of fan illustrated in Figs. 1 and 2, the Electric and Ordnance Accessories Company are also large makers of porthole fans, a type which is in considerable demand for the ventilation of small rooms. The motor in this case is similar in design to those of the A.P. fans just described, the fan blades being of brass, highly polished, and the porthole ring and body of the motor being finished in black enamel. For rooms with low ceilings the makers supply a fan mounted on a tripod, the total depth from the ceiling being only about 9in. The general construction of this type is similar to those already described.

As indicating the solid design of the motors used for these fans, it is interesting to note that the same type of machine is sold as for polishing, small drilling, and general small power services.

* * *

Ferranti Instruments.

Switchboard Transformers.

Among the essentials of modern high-tension switchboards are the current and potential transformers for operating the wattmeters, instruments, and controlling gear, which are, of course, in conformity with modern practice, all at low potential, no matter what the voltage of the board itself may be. As is well known, Messrs. Ferranti, Limited, of Hollinwood, have specialized in

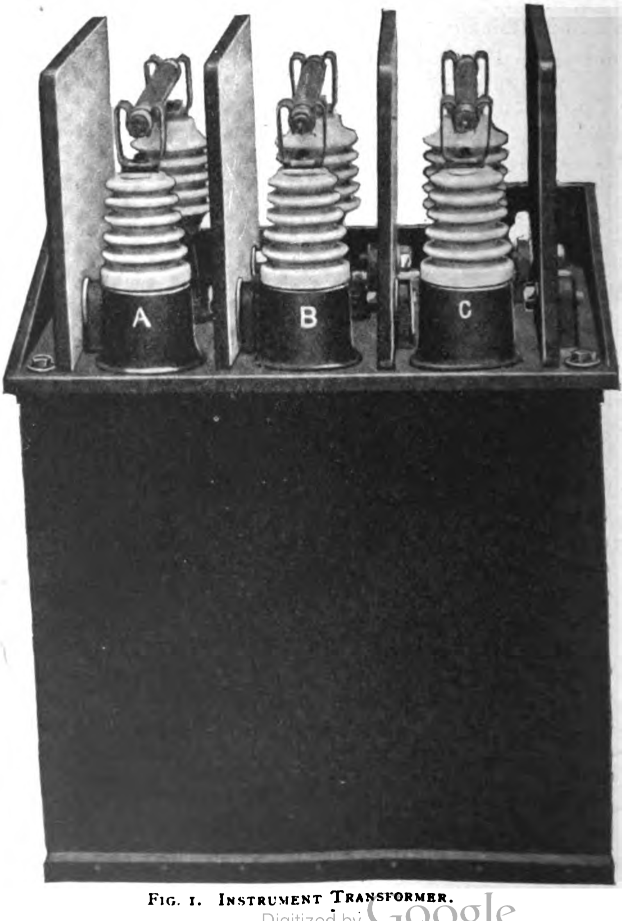


Fig. 1. Instrument Transformer.

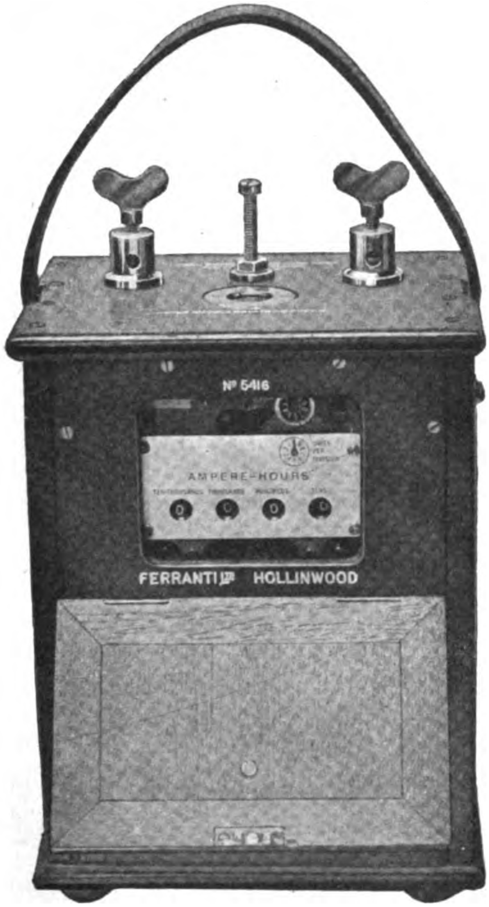


FIG. 2. PORTABLE METER.

this direction, and their standard current and potential transformers have established a very considerable reputation amongst central-station engineers and, although they may not be so cheap as the transformers of some other makers which are at present on the market, it is claimed that on the other hand their greater reliability more than outweighs the extra cost.

Fig. 1 represents one of the recent products of the transformer and instrument department of Messrs. Ferranti. It is from a photograph of a 6000-volt, three-phase, 150-volt-ampere potential transformer complete with primary high-tension fuses. This transformer is contained in a sheet-steel tank, oil-immersed, and is designed to have a negligible drop so that it can operate a number of instruments, wattmeters, synchronising gear, and so forth.

Portable Ampere-hour Meter.

Another recent product of the same department is the portable ampere-hour meter illustrated in Fig. 2. The meter itself is of the well-known standard Ferranti type (Hamilton patent), contained in a polished mahogany case with leather carrying handle, and flap for protecting the front glass. It is provided with lock and key, and rubber supporting feet, and has exterior terminals arranged with winged nuts for ease of making the connections. This portable meter should be very useful for testing house-service meters *in situ*, for testing motors about the works, and so forth.

Reverse Current-relay.

Fig. 3 illustrates a double reverse current-relay for continuous-current circuits, designed by Dr. C. C. Garrard. This relay is intended

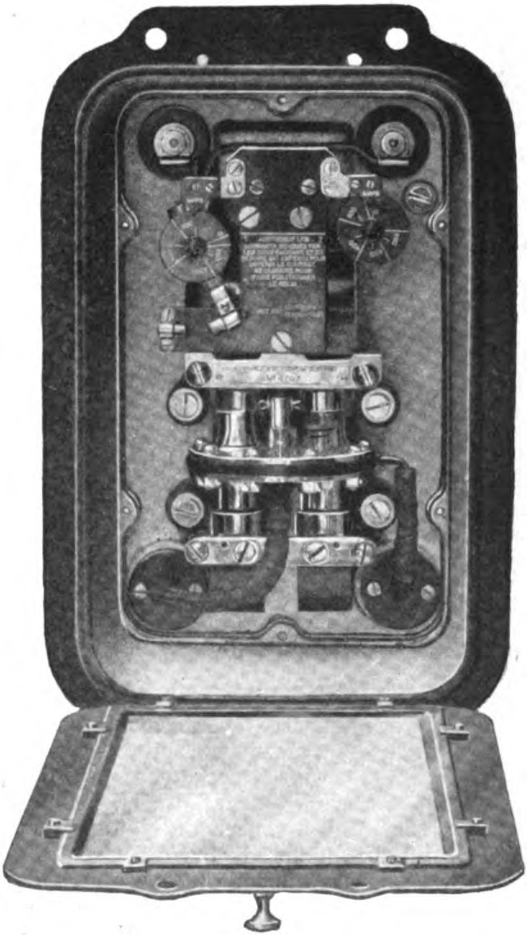


FIG. 3. REVERSE CURRENT-RELAY.

for protecting the continuous-current side of synchronous motor generator sets. Such sets are started from the continuous-current side with a current equal to say 25 per cent. of the normal full-load current, the starting current being of course in the reverse direction to the normal. It is necessary for the machine to be protected against taking too large a starting current. With the machine, however, running as a generator, its circuit breaker should be opened if a reversal of very much smaller magnitude than the starting current occurs. The relay, therefore, is provided with two scales. The reverse current at which it operates is given by the sum of the two readings on the scales. Ordinarily, one scale is on zero, and the other scale set to, say, 10 per cent. of the full-load current. In starting up from the continuous-current side, the setting of the relay is increased by means of the second scale, the resultant setting being given by the sum of the two readings less 100amp. It is necessary to subtract this amount of 100amp. from the sum of the two readings owing to the constant friction, which, of course, is allowed for in the calibration of each individual scale, but naturally comes in twice when the sum of the two scale readings is taken ; therefore it has to be subtracted. This relay acts instantaneously on a reversal of current when the machine is running as a generator, or if too large a current is taken when starting up.

* *

I.M.E.A. Convention.

The Thirteenth Annual Convention of the Incorporated Municipal Electrical Association is to be held in Nottingham from June 30th to July 3rd inclusive. The official programme is now available and indicates that the affair promises to be exceptionally profitable and enjoyable to visitors. Arrangements have been made with the Midland Railway Company by which visiting members can travel to and from Nottingham at reduced rates. The opening day will see the welcome of the Association by the Mayor and Sheriff of the town and will be occupied with the address of the President, Mr. H. Talbot, Chief Electrical Engineer of Nottingham ; this will be followed by a Paper in which Bailie Wightman, of Govan, relates some of his experiences as convener of an electricity committee. After this preliminary dip into the serious business of the convention, members and delegates are to be entertained at luncheon by the chairman (Sir John Turney, J.P.) and members of the Electricity Committee. The rest of the day is to be spent in visiting the electricity and tramways depots of the town. The second day, Wednesday, will evidently be the most arduous : it is to be entirely a day in the country. Whilst for the business days of the Convention 10 a.m. is the moderate time of start, when pleasure is the aim then trains and brakes are quite in order, even though they demand a start being made soon after dawn and a return long after sunset. Thursday will see the Annual General Meeting, at which officers will be elected and next year's convention planned. Two papers are to be read also : Mr. H. Richardson, of Dundee, deals with the design of generating stations ; Mr. Shaw, of Worcester, couples a paper on the reconstruction of an electric lighting scheme with observations on the working of a combined steam and water power plant.

On the Friday, the closing day of the meeting, papers will be read by Mr. A. M. Taylor, of Birmingham, and Mr. H. A. Ratcliff, of Manchester, the former dealing with alternate-current accumulator substations, the latter with the work and equipment of a testing and standardising department.

There are of course many attractions arranged for to fill in the spare time of visitors : the Brush Company have kindly agreed to throw open their Loughborough works for the inspection of members during the Convention ; the electric generating works of the Derby Corporation are also to be open to members.

The secretary of the Association is Mr. C. McArthur Butler, Staple Inn Buildings, Holborn, W.C., to whom anyone interested in this flourishing society of central-station officials should apply for further information.

*

New Catalogues.

Ediswan Fittings.—THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY, LTD.—For many years this firm has published one of the most comprehensive illustrated lists of fittings in the trade, and the new edition just published is far in advance even of that issued last season. In addition to the usual brown-covered edition, which is Part 6 of the standard catalogue, many additional designs of great beauty are included in a supplementary edition. Both these are uniform in size with the other catalogues of the firm, and are punched for insertion in the well-known Ediswan binder.

The catalogues are profusely illustrated, most of the photo-reproductions being one-sixth of the full size, with the exception of a few of the accessories. The illustrations are from photographs of the actual fittings, and may be relied upon in consequence to be an actual representation of the objects.

One of the most useful features of the catalogues is the comprehensive general and numerical indexing, by means of which any fitting can be turned up either under its catalogue number or under its description. This arrangement is to be commended, every class of fitting being brought together under its respective class heading, as plain pendants, hall pendants, ceiling fittings, bronzes, &c., and saving time in referring to any particular type.

EDISWAN FITTING.

EDISWAN FITTING.

The fittings illustrated comprise examples of various styles—from those which, owing to their simplicity and suitability for everyday use, have become more or less independent of fashion, to others which represent the latest and most artistic designs of the artist. A number of entirely new designs are included, but as fresh patterns are continually being brought out by the firm, it is evident that the most carefully compiled list can only contain a selection. Indeed, the firm advise that during the few days that have elapsed since the completion of this catalogue for the press, no less than ten supplementary leaflets, each illustrating from one to four new designs, have had to be printed. Copies of these latter, together with copies of the two catalogue sections, can be obtained from the firm on receipt of trade card.

" Kalkos " Conduits.—THE SUN ELECTRICAL COMPANY, LTD.—Catalogue No. 160 gives a very complete illustrated description of the "Kalkos" (tinned brass tube) conduit system and its standard fittings. This publication is not merely a price list, but contains a good deal of useful information, including hints on estimating, instructions for installations and erection work, &c. As to the fittings, it it is noteworthy that a few parts are so designed as to serve perfectly many purposes; this is an important point as bearing upon the stock which the contractor is required to hold: a small series of boxes and covers are adaptable for either switch, ceiling rose, wall plug, or bracket base. A full description of the "Kalkos" system appeared in THE ELECTRICAL MAGAZINE of October last; it has many points of undoubted superiority over older systems, and promises to become a standard method of interior wiring work.

Adapter Transformers.—LONDON ELECTRIC TRANSFORMER COMPANY, LONDON, E.C. Leaflet directing attention to their remarkable little transformer for use in conjunction with metallic-filament lamps.

Steam Traps.—LANCASTER & TONGE, LTD., MANCHESTER. Descriptive catalogue dealing with the well-known "Lancaster" steam traps and also giving particulars of steam driers. The book is well illustrated and gives dimensions and prices of standard sizes.

Worm Reduction Gears.—REID GEAR COMPANY, LINWOOD, NEAR PAISLEY. Illustrated price list showing a line of self-contained worm gears alone or combined with spur gearing as specially suited for electric drives.

Electric Fittings.—THE ELECTRICAL COMPANY, LTD., LONDON, W.C. Under this title an extremely artistic little booklet has been produced. This book is devoted to an exhibit of one or two examples of the newest designs in fittings. Light brackets, electroliers, dining-room fittings and one or two of the latest designs in heating and cooking apparatus are shown.

Arc Lamps.—THE ELECTRICAL COMPANY, LTD. Price list of new automatic self-focussing "Projector" lamps, and of the A.E.G. Economica Arc Lamp.

Direct-Current Machines.—THE ELECTRICAL COMPANY also send us description of a line of direct-current dynamos and motors. Full details are given of the general construction and performance of these machines.

Small Lighting Plants. IDEAL PLANTS, LTD., MANCHESTER, who recently acquired the business of R. J. Nicholson & Co., send us their new lists descriptive of small petrol-driven self-contained electric-lighting plants. "Light in the Country," now in its 5th edition, explains at considerable length the particular feature which it is claimed differentiates the "Ideal" electrical outfits from any other plant offered for the purpose of lighting country houses, and lays stress on the importance of this feature not only to the householder, but also to the electrical engineer. The booklet is well printed with illustrations of the generating set, the storage battery, switchboard, a general view of an "Ideal" engine room, and small sectional drawings showing the manipulation of the gases in the "Ideal" engine. Publications 84 and 85 accompany "Light in the Country," the former giving prices of sixteen complete plants—engine, dynamo, switchboard, and storage battery—suitable for various-sized houses, while the latter gives detailed particulars and prices for each component of these plants. These publications display considerable care and an understanding of trade requirements. They should prove of some little service in developing the electric lighting of country houses.

Silent Electric Clocks.—G. B. BOWELL, LONDON, E.C. Illustrated price list dealing with a line of British-made silent clocks. These timepieces are made in a variety of types to suit either home, office, or public building.

Ignition Accumulators. — ACCUMULATOR INDUSTRIES, LTD., LONDON, E.C. An attractive little book giving particulars and prices of a series of portable and motor-car cells.

Arc Lamps and Winches.—G. BRAULIK, LONDON, E.C. Two illustrated price sheets, the one referring to the "Aster-Eclipse" arc lamp, which is specially intended to take the place of small flame arc lamps for interior lighting, the other giving general particulars and prices of a series of arc lamp winches.

"Witton" Grip.—ARMORDUCT MANUFACTURING COMPANY, LTD., LONDON, E.C. Catalogue describing the new conduit grip introduced by this firm whereby electrical continuity of a conduit system is secured with ease and certainty.

Automatic Motor Starters.—UNION ELECTRIC COMPANY, LTD., LONDON, S.E. List No. 6020, section 7, gives a fully illustrated description of apparatus which is always of interest to power engineers as providing for the automatic starting, stopping, and regulating of motors. Such apparatus is rapidly coming to the fore in connection with the electric driving of pumps, air compressors, &c.

Arc Lamps.—UNION ELECTRIC COMPANY, LTD. An artistic circular which tells solely by high-class illustrations the uses to which the arc lamps of this well-known company are applied. As the company notes on the title page, they are indeed here shown applied to "every conceivable purpose."

Machine Tools.—TANGYES, LTD., BIRMINGHAM. The 1908 edition of this firm's catalogue of machine tools is a very complete production illustrating and describing a remarkably long list of tools of every type. The book is exceptionally well produced, and should be in the hands of every manufacturing engineer.

Fire Alarm System.—PEARSON FIRE ALARM. LTD., LONDON, E.C. Circular giving short description of the well-known Pearson automatic fire alarm system, a series of illustrations showing buildings protected, and an extensive list of users, testimonials, &c.

Double Reduction Gears.—POWER PLANT COMPANY, LTD., LONDON, E.C. List D.1 will be found of great interest and value by all engaged in motor power work. Printed in two colours and well illustrated, it puts its facts in a concise manner.

Trade Notices.

THE BRITISH ELECTRIC CALIBRATED FUSE COMPANY advise that they have transferred their head office from London to Harpenden, the latter being where the works of the firm are situated. We are asked to advise clients, therefore, that all communications for the firm should be addressed to Harpenden and not to London as heretofore.

THE ARMORDUCT MANUFACTURING COMPANY, LTD., advise us of a change of telephone numbers. They have arranged to have two lines placed upon the easily remembered number 400 Holborn. In view of this change the Company are distributing an alphabetical telephone card which will be found useful.

Dissolution of Partnership.—The business of electrical and mechanical engineers carried on in Motherwell, under the firm name of Hurd, M'Kendrick & Co., of which firm Messrs. Hurd & M'Kendrick were the sole partners, was dissolved by mutual consent on 1st May, 1908. Mr. M'Kendrick has now sole rights to the assets of the dissolved firm, and will discharge its liabilities. The business will henceforth be carried on by him under the name of W. D. M'Kendrick & Co.

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